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STUDY OF AIRCRAFT IN
INTRAURBAN TRANSPORTATION SYSTEMS
SAN FRANCISCO BAY AREA

September 1971

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION


STOL
BOEING

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FOREWORD

This study was performed by the Commercial Airplane Group of The Boeing Company. The Vertol Division provided the helicopter and tilt rotor technology and configuration data.

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Metropolitan Transporation Commission (MTC), Berkeley, California (formerly BATSC/RTPC).—The detailed data on current and projected transportation demand within the greater San Francisco Bay area used in this study were developed by the MTC. The availability of this comprehensive travel data has allowed the study to be conducted on a level of detail much greater than would otherwise have been possible.

Bay Area Study of Aviation Requirements (BASAR), Oakland, California.—Mr. Walter E. Gillfillan, study director, has been most helpful in providing access to air transport projections developed for the BASAR study as well as guidance to other data sources.

Golden West Airlines, Inc., Long Beach, California and Los Angeles Airways, Los Angeles, California.—An appreciation of the trends in indirect costs of airlines operating at very short flight distances was obtained through the cooperation of these airlines.

Pratt & Whitney Aircraft Division of United Aircraft Corporation, East Hartford, Connecticut.—Mr. H. J. Remmer has been most helpful in providing data pertaining to the low-cost and low-maintenance engine.

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FIGURES.–Concluded

1.0 INTRODUCTION

This report presents the results of a study conducted by The Boeing Company under contract to the Advanced Concepts and Missions Division, Office of Advanced Research and Technology, National Aeronautics and Space Administration. The study contract, NAS 2-5969, began in June 1970 and was completed in March 1971. The study was conducted primarily by the Commercial Airplane Group at Renton, with rotorcraft technology and engineering being supplied by the Vertol Division at Morton, Pennsylvania.

The study examines the nine-county San Francisco Bay area in two time periods (1975-1980 and 1985-1990) as a scenario for analyzing the characteristics of an intraurban, commuter-oriented aircraft transportation system. Aircraft have dominated the long-haul passenger market for some time, but efforts to penetrate the very-short-haul intraurban market have met with only token success. Yet, the characteristics of an aircraft transportation system—speed and flexibility—are very much needed to solve the transportation ills of our major urban areas.

In August 1967, The Boeing Company completed the "Study of Aircraft in Short-Haul Transportation Systems," reference 1. That study examined the use of VTOL/STOL aircraft in short-range (50-400 mi—80-644 km) intercity transportation systems, all of which had had some form of CTOL air service for some time. The results showed that both VTOL and STOL aircraft could be economically viable over those ranges.

The present study of aircraft in intraurban transportation systems is concerned with ranges below those investigated in the previous study. This study will attempt to determine if the aircraft can contribute toward solving the transportation problems of major metropolitan areas and be economically viable in such an environment.

The current method of providing for the increased transporation demands in our major cities is to build bigger freeways, add rapid transit (such as the Bay Area Rapid Transit), or both. With freeways becoming less and less popular with amateur and professional ecologists, public transporation systems are being looked on with more favor. Local and national subsidies are available in varying amounts. The flexibility inherent in an aircraft transportation system and its freedom from community-disrupting ground corridors offer some possible improvements over ground systems.

2.0 OBJECTIVES

The principal objectives of this study are:

- Determine the technical,economic,and operational characteristics of a commuter-oriented aircraft intraurban transportation system.
- Determine the sensitivity of these characteristics to changes in the aircraft, market, and operation of the system.
- Identify key problem areas where additional research may result in significant improvement in aircraft transportation systems.

To this end, the study is concerned with the following tasks:

- Developing vehicles appropriate to the commuter-oriented transportation system.
- Establishing a level of technology in each design and operational discipline that is representative of a transportation system starting service in the 1985 period
- Establishing direct and indirect operating cost estimates for the vehicles that reflect the unique operating environment of very-short-range very-high-density commuter operations
- Identifying an air traffic control system concept to cope with the high density of civil air carrier, general aviation, and intraurban aircraft traffic
- Establishing possible terminal sites in the major sections of the Bay area considering aircraft type, flight frequency, ground handling and rapid turnaround, air traffic control, local terrain, alternate terminal use, compatible site and community land utilization, surface accessibility, and passenger convenience
- Establishing realistic passenger demand, mode split, fare structure, and route systems for a base-case transportation system about which sensitivities can be evaluated

The study is primarily oriented towards understanding the transportation system. The specific aircraft designs have not been developed to a high degree but are representative of possible concepts for such a system. Although five concepts were evaluated in the first phase of this study, detailed economic analyses have been completed on only one representative STOL and one VTOL in each time period. A high-speed VTOL, the tilt-rotor aircraft, was included in 1985 to understand the important parameter of cruise speed.

3.0 CONCLUSIONS

The aircraft intraurban system is a technically feasible alternative to ground transportation systems. Although requiring some subsidy, it becomes socially viable where substantial commuter traffic exists at ranges of 10 to 15 mi (18.5 to 27.8 km) or more and where topographic features constrain ground travel. The general problem areas of community noise, air traffic congestion, ground transportation interface, pollution, and safety appear to have workable solutions.

A number of specific conclusions can be drawn from the baseline systems and sensitivity studies described in the summary, section 5.0:

- The VTOL aircraft, although having higher operating costs, show generally superior total economics due to the reduced investment in ground facilities. The VTOL terminals are much smaller than the 2000-ft (610 m) STOLports due to the 3-min gate time used in the study. This low gate time allows a five-gate VTOLport, at less than 8 acres (3.2 hectares), to equal the capacity of a single-runway STOLport of 30 acres (12 hectares). In intercity systems where a gate time of 20 to 30 min is more usual, equal capacity STOLports and VTOLports are more nearly equal in size. Other factors must also be considered, however, in choosing between concepts. It is assumed in this study that all concepts are equally reliable. The level of technology and degree of development required is then another figure of merit for each concept. In view of the current operational status of STOL and VTOL aircraft, it would seem that this required development would be greater for VTOL aircraft in general and the tilt rotor in particular.

- The design field length analysis of the STOL aircraft shows this same relationship. As the field length decreases, the direct operating cost (DOC) increase is overshadowed by the decrease in ground facilities investment.

- The largest single item of cost in each system is the cash direct operating cost (DOC) of the aircraft. The cash operating costs, both direct and indirect (depreciation on aircraft and ground facilities not included), amount to 40% of the total system cost for the STOL aircraft and 60% of the total system cost for the VTOL aircraft. In most systems studied, revenue exceeded all cash operating costs, but, in no systems, were the excess aviation revenues sufficient to cover the cost of sinking funds (capital accounts for replacement of aircraft and terminals) and interest on the long-term debt. If federal funds are available for two-thirds of the total original investment, continuing local subsidy can be substantially reduced and in some systems eliminated.

- The absolute level of air traffic predicted in this study is subject to question due to general uncertainties associated with prediction techniques for passenger acceptance of a new mode of travel. The time/cost relationship used does, however, provide a reasonable interaction between system elements and the resulting passenger demand that is fundamental to the objectives of this study.

- Cruise speed (up to 250 kn–463 km/hr) is an important parameter even at the very short ranges of the intraurban system. This is demonstrated by the effect of technology on the 1985 helicopter where the cruise speed is increased from 170 to 210 kn (315 to 389 km/hr). This increased speed attracts more passengers, lowers DOC at longer ranges, increases productivity, and results in a 46% lower loss per passenger. For the STOL aircraft, reducing the cruise speed to 200 kn (370 km/hr) from 325 kn (602 km/hr) increases the loss per passenger by 24%. For cruise speeds above 325 kn (602 km/hr), the gain is negligible.

- While high cruise efficiency and low structural weight are still important to a very-short-range aircraft, the sensitivity of the gross weight to these factors is very much less than for an intercontinental aircraft. For the intraurban aircraft, the resulting cost/weight trades heavily favor those structural concepts in which some weight penalties are taken to reduce manufacturing cost and operating cost and increase reliability and maintainability.
- Propulsion systems with low maintenance and low manufacturing cost as prime design goals (allowing some increases in specific fuel consumption and weight) also show favorable trends in total system cost.

- Low gate times are very important to an intraurban system. They allow a reduced fleet size, lower ground facilities investment, and lower IOCs. The savings are much greater than the increase in the per-aircraft and per-gate costs necessary to achieve low gate times.

- The extreme peaking characteristics of a commuter-based system have a major effect on system operations and economics. The peaking predicted for this study increases cash operating costs by 10% and fleet size by 60% when compared to a system with a constant demand over an 18-hr day.

- The downtown ports, although the most costly, contribute the greatest amount of passenger demand and operating revenues. The service to the community is greatest here also in the form of relief to congested roads, bridges, and parking lots.

- The intraurban system is not economically feasible under current air traffic control (ATC) procedures and regulations. Some form of fourth-generation ATC must be introduced that will provide for reduced separation at busy STOLports and strategically controlled, time-synchronized operation. A large development effort is not necessary to achieve a satisfactory system for use within the geographic area of the study.

- It is difficult, if not impossible, to develop unit cost for cargo movement competitive with surface modes. As a result, system losses cannot appreciably be reduced by direct competition with ground transportation. Only where major system cost savings can be found for such items as high-value goods, and time-critical commodities, is some loss amelioriation possible. However, because the intraurban system will probably rely to some extent on subsidy, competition with other commercial cargo transportation systems might well be limited, except for public service such as mail.

- Community noise from intraurban aircraft, does not in itself seem to be sufficient justification for eliminating the aircraft system as an alternative to other modes of transportation. As long as the aircraft-generated noise exceeds the background noise level, however, some opposition will appear. To give the aircraft system a reasonable chance, substantial effort must continue in areas of research directed toward STOL and VTOL aircraft noise reduction.

- When the Bay Area Rapid Transit System, as it will exist in 1975, is added to the analysis of the aircraft system, those routes that are served by BARTD are dropped from the aircraft system. This results in a loss of 45% of the demand and an increase in the loss per passenger for the remainder of the aircraft system. It would appear that an optimum mix between ground and airborne transportation systems could be found. The ground-based systems are at their best over very short ranges serving very dense populations. The airborne system is at its best at the longer intraurban ranges, offering fast transportation to a much greater area, with the added ability of being able to respond rapidly to changing community needs.

- A logical STOL network would begin service with a STOLport as near downtown San Francisco as possible and serve terminals at other existing airports surrounding the bay, including the three major airports.

- A high-speed intraurban transporation system tends to expand the job opportunity area of the central business district. To the extent this is considered desirable, the aircraft intraurban system is a reasonably cost-effective method of accomplishing this purpose.

- Although the study was specifically for the San Francisco Bay area, many of the results can be applied to other large metropolitan areas. This cannot be done, however, by the use of simple demographic criteria (population, area/density ratio, etc.). Topographical barriers separating areas of high density have a substantial effect on the size of the intraurban system required.

4.0 RECOMMENDATIONS

As a result of this study, some key problem areas are identified where additional research or study would contribute significantly toward bringing about improved transportation systems. The intraurban aircraft can generally benefit from technical research on all VTOL/STOL aircraft. There are some items in the following list, however, that are particularly important to the intraurban system. The items are separated into two areas, those that are primarily technical and those that are primarily systems analysis.

- Technology
  - Community acceptance criteria for aircraft noise
  - Noise suppression techniques for all concepts
  - Landscaping and architectural techniques for shielding nearby communities from terminal noise
  - Design standards for VTOL/STOL intraurban aircraft
    - Maneuver and stall margins for powered lift concepts
    - Design field length rules
    - Control response and handling characteristics requirements
    - Attitude and acceleration limits for passenger acceptance
  - Autoflight - takeoff through landing — maximum safety,
  - Terminal and en route navigation — minimum weather delays
  - Air traffic control techniques and displays
  - Reliability and maintainability
    - Lift systems
    - Control systems
    - Landing and navigation systems
    - Propulsion system
  - Propulsion system dynamics and integration
    - Cruise mode for valveless augmentor wing
  - Advanced structures
    - Materials
    - Design concepts
    - Cost/weight trades at intraurban design ranges
  - Propulsion-lift/aerodynamic-lift trades
  - Gust alleviation for ride comfort, controllability, and wake turbulence
  - Rooftop STOLports
    - Turbulence
    - Emergency arresting equipment

- Systems Analysis
  - Modal-split techniques
    - Passenger preference factors
    - Value of time
  - Relative safety between competing modes
  - Intercity use of intraurban terminals
  - Relative total economic impact on community of competing modes of travel
  - Impact of possible local restrictions on use of automobile

- Strategic air traffic control simulation
  - Weather limitations
  - STOL traffic demands
- Optimum mix of air and ground intraurban transportation systems
- Political and ecological impact
- Specific off-peak utilization for intraurban aircraft in San Francisco Bay area
  - System benefits to high-value and time-critical commodities
  - Possible surface competition development
  - Passenger service to northern California urban and recreational areas

This study did not examine a large number of concepts but concentrated mainly on the analysis of a representative aircraft system. Some effort should now be undertaken to investigate many vehicle concepts for relative suitability in this area. Perhaps even more important, however, would be an in-depth analysis of one concept to investigate, in detail, certain areas of prime importance to an intraurban system such as: maintainability and reliability at minimum turnaround times; structural design concepts for minimum-cost vehicles; propulsion systems designed for low noise, maintenance, and manufacturing cost; etc. . . .

5.0 SUMMARY

A summary of the major results in each area of the study is presented in this section. Expansion on each of these subjects can be found in the main body of the report.

5.1 STUDY TRANSPORTATION SYSTEM

The nine counties of the San Francisco Bay area, figure 5-1, are the subject of this intraurban transportation study. Shown on this map are the locations of postulated air terminals and their identification numbers, which are referred to from time to time in this report.

The terminals have been located as close to the passenger origin and destination (O&D) demand as possible within the constraints of noise and compatible land use, air traffic control (ATC) considerations, ground access, and weather considerations. In the suburban areas, existing general aviation airports have been used where possible, and service is provided to the three major regional airports.

The total daily travel demand for this area is shown in figure 5-2 for 1980 and 1990. These are aggregated trips from the area nearest one terminal to the area nearest any other terminal shown in figure 5-1. These travel data have not been estimated here, but are based on data supplied by the Metropolitan Transportation Commission (MTC) in Berkeley, California. The MTC data were based on comprehensive home surveys and cordon surveys in 1965 and expanded by them to 1980 and 1990 by detailed forecasting processes using many demographic features and historic data. The trip-demand data were supplied to this study in the form of a matrix of daily passenger trips between any of 291 analysis zones. These trips have then been grouped by a modal-split model into interterminal trips as shown in figure 5-2.

The decrease of travel demand with range is typical of a metropolitan area that includes commuter travel. The aircraft system is most suitable at the longer ranges of this trip demand, although some trip distances as low as 6 mi are considered.

5.2 CONFIGURATIONS AND TECHNOLOGY

Five major concepts representing both STOL and VTOL in three passenger capacities and two time periods have been analyzed in this study. The three best concepts in a nominal 100-passenger capacity are shown in figures 5-3 through 5-5. The two additional concepts, a conventional STOL and a jet VTOL are discussed in the configuration section (6.0). They were not included in the detailed economic analysis as initial results showed them to be less profitable, and time allowed only one representative VTOL and one representative STOL aircraft to be analyzed in depth. The tilt-rotor VTOL was included to show the effect of speed on system economics.

Two time periods are anlayzed in this study: a near term and a far term. The near-term aircraft are designed with today's technology with introduction of service to begin in 1975. The system analysis for these aircraft is based on the 1980 MTC travel demand, which represents a midlife point for the 1975 aircraft.

The far-term aircraft are designed using advanced technology applicable to an aircraft starting service in 1985. The system analysis for these aircraft is based on the 1990 MTC travel demand, which again represents the midlife for the aircraft.

The concepts all use the "European Train" compartment-type fuselage, with a door on each side of the airplane leading into a compartment with facing seats. Sensitivities are included later for more normal aircraft seating arrangements. The vehicles are designed with simplicity and low cost (both initial and operating) as the prime consideration, as cruise efficiency is of little importance at the operating range considered here. Tables 5-1 and 5-2 summarize the general characteristics of the concepts, and tables 5-3 and 5-4 present the weight summary for each concept for two typical design capacities. The gross weights are plotted against passenger capacity in figure 5-6, and the air trip time (block time) is presented in figure 5-7.

5.3 OPERATING COSTS

Both direct and indirect operating cost estimates are made as a result of component-by-component analyses of both the aircraft and the transportation system. Table 5-5 shows the total aircraft acquisition price and also breaks down the total price to airframe, electronics, and engines. The low prices are primarily a result of very simple structure (and hence manufacturing techniques) and a much larger than normal production quantity (2000). The production quantity is based on the assumption that if the system is feasible in the San Francisco Bay area it will also be feasible in many other major metropolitan areas around the world.

The cash direct operating costs (DOC) are presented for the 1975 concepts in figure 5-8 and for the 1985 aircraft in figure 5-9. They are shown as trip cost versus range rather than the more usual "cents per seat mile" in order to show the cost down to very short ranges. The depreciation of the aircraft is not included here because all investment costs are treated separately in the economic analysis. The steeper slope of the helicopter DOCs reflects the slower cruise speed of this concept.

For a typical range of 30 mi (56 km), figures 5-10 and 5-11 show a breakdown of the operating cost by major category. These figures also show the allocated depreciation (dotted lines) for one possible utilization of 5 hr/day (1550 hr/year).

The results of the component-by-component analysis of the indirect operating costs (IOC) is shown in table 5-6. Each cost category in the IOCs is related to the seven causal factors in coefficient form. The resultant equation, shown in table 5-6, has been used in the comprehensive computer analysis of each system. Table 5-7 compares the IOCs for the base intraurban system with other more familiar levels of service.

As with the DOCs, the IOCs do not include any investment costs or depreciation. The total ground system investment for the base STOL and base VTOL system are shown in table 5-8. These include all the costs for the aviation-oriented facilities required for the terminals. The cost of providing facilities for concession operators and excess space available for other rentals is assumed to be covered by their associated income. The maintenance facilities for the systems shown in table 5-8 require an additional investment of $19 000 000.

5.4 NETWORK ANALYSIS

The usual approach to the economic analysis of an aircraft transportation system is to estimate aircraft utilization, average load factor, and other important parameters based on the past history of such systems. The use of aircraft in an intraurban system has no such past history. The very short ranges and highly peaked and directional passenger demand of a commuter-oriented system make the estimate of important system parameters very difficult. The use of these estimated parameters then casts grave doubts on any results forthcoming from the analysis.

In this study, a comprehensive transportation network model is used that eliminates the need to estimate the important parameters of the system, thereby allowing greater confidence to be placed in the results. The network model takes aircraft passenger demand (as a function of time of day) for each link in the system and constructs a complete schedule of aircraft flights for one typical day in the system. The cash DOCs are summed for each flight, including any required ferry flights. The IOCs are calculated based on the causal factors developed in the model: number of terminals, departures, gates, passengers, etc. The aircraft and ground system investments are summed and the resultant annual interest costs and required sinking funds calculated. A detailed economic analysis can then be performed. Depreciation is accounted for by the sinking fund method of amortization, where interest-gathering capital accounts are set up for replacement of aircraft after 10 years and terminal facilities after 20 years.

The aircraft passenger demand input for the network model is obtained from a modal-split model that operates on the detailed total trip demand in the Bay area received from MTC. For each passenger trip, the time and cost for the auto trip are calculated and compared with the time and cost for the air trip. The auto trip cost is based on 40% single-occupant travel with 60% of these, or 24% of the total travelers, using total auto costs including depreciation and insurance in their mode comparison. The remainder of travelers see their auto cost as out-of-pocket incremental expense only.

The air trip cost is the sum of twice the incremental auto cost to the nearest terminal (kiss and ride), the air fare, and a 15-cent average bus fare at destination.

These relative times and costs are then compared and the passengers willing to take the air mode determined as follows:

- Where door-to-door trip times and costs are exactly equal, 50% of the travelers will take the air mode.
- Where door-to-door trip times are equal, no one will take the air mode if its costs exceed the auto costs by $2.00 or more.
- Where door-to-door trip costs are equal, everyone will take the air mode if they save 30 min or more of trip time.

A method of predicting passenger acceptance is included here for two important reasons: first, to show the sensitivity of this demand to changes in system variables (e.g.,

fare, terminal location, speed, gate time) and, second, to obtain the level of traveler demand for the air mode.

The base air fare used in the study is shown in figure 5-12. The resultant demand from the modal-split model for variations of this base fare are shown in figure 5-13 for 1980 and figure 5-14 for 1990. As the air fare is decreased, the air mode becomes attractive to the large number of short-distance travelers, causing the average trip distance to reduce also.

An example of the results of the network model using the 1980 passenger demand for the base air fare and the 49-passenger augmentor wing STOL airplane are shown in table 5-9.

5.5 ECONOMIC COMPARISONS

With the results of the network model for each aircraft in its respective time period, the concepts can now be compared on a total economic basis. Figure 5-15 shows the daily cash operating costs, sinking funds, interest on investment, and revenue for the three passenger capacities of the two 1975 concepts flown in the 1980 time period. Figure 5-16 displays the same information for the 1985 aircraft flown in the 1990 time period.

Several interesting relationships can be observed from these figures. Although the operating costs for the 1975 helicopter are higher than the augmentor wing STOL, its much reduced terminal investment reduces the loss by 34%. This same effect is shown for the 1985 aircraft in 1990. The slower block speed of the helicopter causes it to carry fewer passengers than the STOL where the VTOLports and STOLports are located at the same place. Where the VTOLports are closer to the passenger demand, this speed difference is more than made up. The 50-passenger helicopter system in 1980 carries 8% more passengers than the STOL system. The tilt-rotor VTOL aircraft combines the two favorable effects. It has the high speed of the STOL and operates from the closer-in VTOLports. The result is the most profitable aircraft studied, carrying 36% more passengers in 1990 than the augmentor wing STOL.

For the STOL aircraft in both time periods, the investment cost and sinking funds for aircraft and terminal replacements account for an average of 58% of the total daily costs. The VTOL aircraft reverse this ratio, so that 60% of the total costs are cash operating costs and 40% investment and sinking fund costs.

In all cases, the smallest aircraft (50 passengers) has the smallest total loss and least loss per passenger. As the capacity increases, the average load factor, frequency of service, and total passengers carried reduce causing the increase in loss per passenger.

As all systems show that cash operating profit is not sufficient to supply the required cash for debt costs and sinking funds, outside sources of cash are needed. Possible sources of funds include local and federal subsidies and grants and income to the intraurban system from concessions and leases. Figures 5-17 through 5-21 show five possible cash flows (A, B, C, D, and E) for the best STOL and best VTOL in each time period;

A All loss is covered by local subsidy.

B Concessions and leases are assumed to pay for 50% of the aviation-oriented terminal investment and sinking funds (in addition to paying for the cost of providing the concession and lease space). All other losses are payed for by local subsidy.

C Same as B except concessions and leases pay 100% of the terminal investment and sinking funds.

D A federal grant is assumed to pay for two-thirds of the total initial investment, as has been proposed for ground mass transit studies. Concessions and leases pay half of the remaining terminal investment costs and half of the terminal sinking fund. Again, local subsidy covers the remaining loss.

E Same as D except the local subsidy is reduced by 50% with this amount being covered by continuing federal matching funds.

The general effect of these postulated subsidies and concession and lease income assumptions is to bring the required local subsidy for the STOL systems down to a level comparable to the helicopter systems. For the tilt-rotor VTOL, the required local subsidy becomes zero for plans C, D, and E. Plan D appears to be the most probable plan and should be used for estimating the impact on the community.

5.6 SENSITIVITY STUDIES

In addition to the base airplane comparisons presented in section 5.5, a number of analyses are made to show the sensitivity of the basic results to the more important parameters of the study.

At this point, a moment of reflection is in order. As the sensitivity studies were made for this report, each new sensitivity uncovered relationships that provided new insight to this totally new problem of using aircraft in an intraurban commuter transportation system. The base systems were adjusted twice in an attempt to keep them near optimal. However, some of the final sensitivities suggest that more optimal combinations exist that would further reduce required subsidies or losses per passenger. Further difficulty is added by the lack of a well-defined criterion of excellence that is applicable to all systems.

To provide some measure of the contribution of the technology advances assumed for the 1985 aircraft, the cash flow comparison of figure 5-22 is presented. It shows the relative cash flows for the 1975 STOL and VTOL operating in the 1990 environment and compares these with the 1985 aircraft in the same environment.

For the augmentor wing STOL aircraft, the advanced technology results in a 13.5% reduction in cash DOCs. This reduces total costs by only 4.5%, but the total loss and, therefore, loss per passenger is reduced by 10%.

The technology advancements for the helicopter result in a 19% reduction in cash DOC per trip with a 24% increase in cruise speed (170 to 210 kn—315 to 389 km/hr). This increased cruise speed attracts 11% more passengers, as reflected in the additional revenue

shown. The total cash flow for the 1985 helicopter in the 1990 market is 5% lower than the 1975 helicopter, but the net loss is reduced 39% and this reduced loss, spread over the greater number of passengers carried, results in a 46% lower loss per passenger.

The effect of design field length for the augmentor wing STOL in 1975 is shown in figure 5-23. The general decrease in cash DOC of 19% by increasing field length from 1000 to 3000 ft (305 to 915 m) is overshadowed by the 45% increase in sinking fund and interest costs. The investment in ground facilities increased 57% while the aircraft investment reduced 15%. Including the cost of the STOL terminals in the analysis (as shown) suggests that the 1000-ft (305-m) STOL is best. If cash flow plan D from section 5.5 is used here, the reverse could be shown. Plan D essentially eliminates the effect of the increased STOLport costs as the federal grant and concession income pay for all but one-sixth of their cost.

It can be concluded, however, that for the augmentor wing powered-lift STOL, the total cost of the system can be reduced by designing to as low a field length as 1000 ft (305 m). The loss or subsidy per passenger required at 1000 ft (305 m) is 9% lower than at 2000 ft (610 m).

Figure 5-24 shows the effect on total loss per passenger of flying the STOL aircraft at much slower cruise speeds. The lower cruise speeds increase the cash DOC per trip and decrease the available market. The net effect is a 24% increase in the loss per passenger as the cruise speed is cut from Mach 0.59 to Mach 0.3.

The impact of increased gate time for the augmentor wing STOL is shown in figure 5-25. The basic designs all use the type I interior ("European train") and operate with a 3-min gate time. The type II interior is modified from the type I by joining compartments in pairs and removing every other door. The type III interior is more conventional with four-abreast seating and four doors but still allows a gate time of 5 min if the engines are kept running and the passenger elevators are automated as for the base-case intraurban system. The incremental loss for the conventional interior operated at the same gate time as the type I is only 15 cents per passenger. The major effect on system cost is directly attributed to the unproductive time spent at the gate. This has a twofold effect: first, fleet size must be increased to carry the same number of passengers through the peak periods of the day, and, second, the terminals must be expanded to include the additional gates required. The IOC also increases by the manpower required for the additional gates. The net effect of increasing the gate time for the type I aircraft by 5 min (3 to 8 min) increases the loss per passenger by $1.05 or 26%.

If the price of the augmentor wing STOL were based on a more typical production quantity (300 to 400 versus 1500 to 2000), the price/cost would increase by about 60%. The effect of this increase on the cash flow is illustrated in figure 5-26. The cash DOC is increased 12%, and the total costs are increased 11%. The resultant loss per passenger is increased 21%.

The passenger demand, as a function of time of day, is typical of rush-hour traffic in any large city. The effect of this highly peaked demand is shown in figure 5-27. Data scatter is due to differences in optimality of the schedules produced by the network model for the various degrees of peaking. Eliminating the peaks allows a much smaller fleet of aircraft to

carry the same number of people during one day's operation. This allows an increase in daily cash operating profit (revenue minus cash DOC and IOC) of $18 000. Increasing the relative peaking has a decreasing effect primrily because a high percentage of the travelers were already in the peaks in the base case (1.0).

Figure 5-28 illustrates the effect of varying the base fare. The results are a good example of why a scheduling model is necessary to find true sensitivities. The base fare was determined by an analysis outside the network model (sec. 11.3) using a constant load factor.

That analysis showed the base fare to have near-optimal loss per passenger. With the scheduling model calculating the load factor, a different answer is found. As the fare is reduced, each link carries more passengers. The effect of density on a link is to increase the average load factor. As load factor increases, the cost per passenger decreases almost proportionally. In addition, as the demand increases substantially, new links are added to existing terminals further reducing the investment and sinking funds per passenger for that terminal. The net effect is that the loss per passenger is continuing to decrease at the lowest fare shown. Following the incremental trends indicates a minimum loss per passenger of $1.25 at a fare equal to 55% of the base fare.

The effect of eliminating the STOLports in downtown San Francisco is shown in figure 5-29. Eliminating STOLport 1, which is located over the ferry building at the foot of Market Street, reduces the demand by only 2000 passengers and results in a reduction of 23 cents (5%) in the loss per passenger. The passengers usually carried through terminal 1 were carried through terminal 3, and the majority of the cost savings is in the investment and sinking funds for the $88 000 000 terminal at zone 1. As the remainder of the terminals near downtown San Francisco are eliminated, the system loses over 40% of the passengers carried in the base system. The net loss is decreased, but the loss per passenger carried is increased 15%. However, factors not included in the above cash-flow analysis are perhaps more important. Leaving out the three downtown terminals eliminates service to the prime business center for the area, resulting in no reductions in the number of automobiles using the bridges into downtown San Francisco and no relief for congested streets and parking areas in San Francisco.

The primary purpose in including the modal-split function in the systems analysis loop is to show the interaction between system variables and passenger demand. This modal-split function is nothing more than a mathematical model of the decisionmaking process used by the real-world traveler in choosing a mode of travel. The number of factors used by this real-world traveler in choosing a mode is obviously much greater than is used in the simple modal-split model described in section 5.4 (and in much more detail in section 11.1.2). In addition, each traveler uses a different set of factors or at least weighs each factor differently in arriving at his decision.

The relationship used here reduces the decision to one of comparing time and cost for each mode. The effect on demand of varying the intercepts to the modal-split plane is shown in figure 5-30. The most sensitive of the intercepts is ΔC_0, the additional cost of the air mode where penetration goes to zero (at equal trip times).

5.7 BARTD COMPARISON

Although the primary motive for any modern public mass transportation system is to replace all or part of automobile traffice in a given area, it is inevitable (and proper) that the competing methods of mass transit be compared. In the San Francisco area, BARTD is scheduled to begin initial service in the fall of 1971. It seems appropriate, then, to compare the aircraft intraurban system with BARTD, as shown in table 5-10. The data presented here for BARTD comes from references 2 and 3.

The BARTD system is primarily a short-range system, carrying 85% of its passengers less than 16 mi (26 km), while the airplane system carried 83% of its passengers more than 16 mi (26 km). It is estimated that both systems capture about the same number of auto passengers (60 000 versus 50 000), although the automobile road miles saved by the airplane system will be twice that saved by BARTD, due to the much longer average range of the airplane system.

BARTD carries four times the number of passengers carried by the intraurban system. However, in productivity (revenue passenger-miles), BARTD is only 50% higher than the intraurban system. The initial investment for BARTD is 75% to 200% more than the intraurban system resulting in an annual cost to the taxpayers of 100% to 200% more.

The basic system analysis in this study has assumed that no ground rapid transit (BARTD) is available. Figure 5-31 shows the effect on the system economics if the intraurban system must compete with BARTD as it will exist in 1975. The fares for the highly subsidized BARTD system at ranges over 10 mi (16 km) are less than the out-of-pocket expense of operating a car.

The intraurban system cannot compete with BARTD between the same points. When links with direct competition by BARTD are eliminated, the intraurban system carries 45% fewer passengers. The loss per passenger rises to $6.93, an increase of 70%.

5.8 COMMUNITY SUITABILITY

There are many criteria to be considered in judging community acceptability of a new transportation system. In the case of the intraurban system, probably the most critical criterion is community noise. Additional criteria considered are relative safety, pollution, and air traffic control congestion.

Community noise and compatible land use are two of the most important considerations in locating terminals in this study. The assessment of the impact of aircraft noise on the community takes into account the noise level, the frequency of flights, the time of day (whether day or night), and the amount of ambient noise already present in the vicinity of concern.

The system used for describing the reaction of people to noise is the noise exposure forecast (NEF) (ref. 4) modified to include the effects of ambient noise NEF_A. Figures 5-32 through 5-39 show contours of constant NEF_A for the 1975 augmentor wing STOL and

helicopter using the frequency of operations from the base 1980 systems. For reference, a 95-EPNdB contour is included in figures 5-32 and 5-33. These contours apply to all port locations as they are not a function of background noise or number of movements.

Noise criteria for an intraurban system should strive for acceptability rather than test the endurance of the people it affects. Robinson's criterion (ref. 5) of 85 PNdB, which he considers the maximum allowable in a quiet residential area, corresponds approximately to a preferred speech interference level (PSIL) of 65 dB, which will permit uninterrupted speech communication over distances of 2 to 8 ft (0.6 to 2.4 m). This is consistent with communication requirements for domestic recreation activities and other pursuits accompanying which conversation is common and desirable. The corresponding NEF_A is, therefore, established as 10 for residential areas and 15 for industrial areas.

The addition of a large number of flights (2000-3000) over a densely populated metropolitan area raises the question of relative safety of the aircraft to other modes of travel. The figures on fatal accidents per million departures for U.S. scheduled air carriers show a continuing improvement with time. For 1969, this number was 1.5 fatal accidents per million departures. Many factors must be used to modify this number for the intraurban system. On the favorable side are time, approach speed, and automation. Unfavorable factors include the ratio of available to required field lenth and air congestion.

It is assumed here that the continuation of accident rate improvement with time, and the reduction of landing accidents resulting from automatic landing equipment will overcome the unfavorable factors mentioned and result in an accident rate for the intraurban system of 0.5 per million departures. This rate for the base system would result in a long-term average of 4.7 passenger fatalities per year. The air system would, however, remove a substantial number of automobiles from the highways which is estimated to save at least a similar number of lives per year. The intraurban system would then contribute no additional fatalities.

The augmentor wing STOL aircraft will emit approximately 2 lb (0.9 kg) of pollutants per 1000 mi (1609 km) per passenger carried. Existing automobiles emit approximately 212 lb (96.1 kg) per 1000 automobile miles (1609 automobile km). If all autos are modified to meet 1972 federal standards, this is reduced to 60, and proposed 1975 federal standards further reduce the number to 20. This is still one order of magnitude above the intraurban system assuming a single occupant per automobile. Further improvements are expected for both the automobile and aircraft by 1985. The augmentor wing STOL emissions should reduce by a factor of three.

The inclusion of 2000 to 3000 additional flights into the Bay area would cause unacceptable congestion and delays if the intraurban aircraft were controlled by the same procedures used for today's tactical IFR movements. The intraurban system must be controlled by one of the possible fourth-generation ATC systems. For this study, a strategically controlled time-synchronized system is assumed. A central ground-based computer would handle all control and scheduling for the fleet, directing their automated flight by a data-link communications system. In addition, for the downtown STOLports of the larger systems studied, an increase in today's runway acceptance rate is required during the morning and evening peak movement periods.

In the 1985 to 1990 time period, the present tactically controlled flights would be merged with the intraurban flights into a single fourth-generation system. In both time periods, the dense intraurban links would use dedicated airspace. This will reduce, somewhat, the amount of free space available for uncontrolled VFR flights but will not eliminate it.

From the factors considered, it would seem that the aircraft system can make a meaningful contribution to the transportation needs of the area without becoming an unwelcome neighbor. This is not to say that the local populace around suggested terminal locations will not object. The airplane in the past has been a rather noisy neighbor, and a large public relations effort will be needed to eliminate this image.

TABLE 5-1.–GENERAL CHARACTERISTICS–50-PASSENGER AIRCRAFT

Airplane components	1975 augmentor wing STOL	1985 augmentor wing STOL	1975 helicopter	1985 helicopter	1985 tilt-rotor VTOL	1975 augmentor wing STOL	1985 augmentor wing STOL	1975 helicopter	1985 helicopter	1985 tilt rotor VTOL	Units
	English units					International system of units					
Wing span, ft	63.6	47.4			51.1	19.4	14.4			15.6	m
Area, sq ft	675	375			408	62.7	34.8			37.9	m^2
Aspect ratio	6.0	6.0			6.43	6.0	6.0			6.43	
t/c, %	21.0	27.0			21.0	21.0	27.0			21.0	%
Rotor diameter, ft			56.0	56.0	37.2			17.1	17.1	11.3	m
Disc area, sq ft			4 926	4 926	2 174			457.6	457.6	202.0	m^2
Number of blades			4	4	3			4	4	3	
Body length, ft	61.0	61.0	64.0	64.0	62.5	18.6	18.6	19.5	19.5	19.0	m
Diameter, in.	130.5	130.5	120.0	120.0	130.5	3.31	3.31	3.05	3.05	3.31	m
Number of engines	2	2	4	4	4	2	2	4	4	4	
Thrust-power per engine	7 240 lb	6 900 lb	1 844 hp	1 650 hp	1 967	3 284kg	3 130 kg	1 377 kW	1 230 kW	1 468 kW	
OEW, lb	24 160	17 497	27 269	22 737	20 365	10959	7937	12369	10314	9238	kg
Payload, lb	9 800	9 800	10 000	10 000	10 000	4445	4445	4536	4536	4536	kg
Max taxi weight, lb	37 118	29 977	40 289	35 142	32 240	16837	13598	18273	15940	14624	kg
Field length, ft	2 000	2 000				610	610				m
Range, nmi	100	100	100	100	100	185	185	185	185	185	km
Cruise speed, kn	325	325	172	214	302	602	602	319	396	559	km/hr
Wing loading, lb/ft^2	55.0	80.0			79.1	268	391			386	kg/m^2
Thrust loading, lb/lb or HP/lb	0.39	0.46	0.183	0.188	0.244	0.39	0.46	.301	.310	.402	kg/kg or w/g
Payload/GW	0.264	0.327	0.248	0.285	0.310	0.264	0.327	0.248	0.285	0.310	

TABLE 5-2.–GENERAL CHARACTERISTICS–100-PASSENGER AIRCRAFT

Airplane components	1975 augmentor wing STOL	1985 augmentor wing STOL	1975 helicopter	1985 helicopter	1985 tilt-rotor VTOL	1975 augmentor wing STOL	1985 augmentor wing STOL	1975 helicopter	1985 helicopter	1985 tilt rotor VTOL	Units
	English units					International system of units					
Wing span, ft	81.1	60.4	–	–	67.0	24.7	18.4	–	–	20.4	m
Area, sq ft	1 097	607	–	–	758	101.9	56.4	–	–	70.4	m^2
Aspect ratio	6.0	6.0	–	–	5.92	6.0	6 0	–	–	5.92	–
t/c, %	21.0	27.0	–	–	21.0	21.0	27.0	–	–	21.0	%
Rotor diameter, ft		–	75.75	75.75	50.7	–	–	23.1	23.1	15.5	m
Disc area, sq ft		–	9 012	9 012	4 037	–	–	837.2	837.2	375.0	m^2
Number of blades	–	–	4	4	3	–	–	4	4	3	–
Body length, ft	86.0	86.0	82.5	82.5	88.7	26.2	26.2	25.1	25.1	27.0	m
Diameter, in.	145.0	145.0	160.0	160.0	145.0	3.68	3.68	4.06	4.06	3.68	m
Number of engines	2	2	4	4	4	2	2	4	4	4	–
Thrust/power per engine	11 770 lb	11 170 lb	3 380 HP	3 075 HP	3 670 HP	5 339 kg	5 067 kg	2 520 kW	2 295 kW	2 740 kW	–
OEW, lb	36 408	25 393	48 226	40 604	36 699	16 515	11 518	21 875	18 418	16 647	kg
Payload, lb	19 000	19 000	19 600	19 600	20 000	8 618	8 618	8 891	8 891	9 072	kg
Max taxi weight, lb	60 350	48 580	73 756	65 074	60 039	27 375	22 036	33 456	29 518	27 233	kg
Field length, ft	2 000	2 000	-		-	610	610	–	–	–	m
Range, nmi	100	100	100	100	100	185	185	185	185	185	km
Cruise speed, kn	325	325	172	214	320	602	602	318	396	593	km/hr
Wing loading, lb/ft^2	55.0	80.0	–	–	79.3	268	391	–	–	387	kg/m^2
Thrust loading, lb/lb or HP/lb	0.39	0.46	0.184	0.189	0.244	0.39	0.46	.303	.311	.402	kg/kg or W/g
Payload/GW	0.315	0.391	0.266	0.301	0.333	0.315	0.391	0.266	0.301	0.333	

TABLE 5-3.—WEIGHT SUMMARY—50-PASSENGER AIRCRAFT

Airplane components	1975 augmentor wing STOL	1985 augmentor wing STOL	1975 helicopter	1985 helicopter	1985 tilt-rotor VTOL	1975 augmentor wing STOL	1985 augmentor wing STOL	1975 helicopter	1985 helicopter	1985 tilt-rotor VTOL
			lb					kg		
Wing	4 126	1 573			2 111	1 872	714	-	-	958
Horizontal tail	625	311			437	283	141		-	198
Vertical tail	377	202				171	92	-	–	
Body	6 678	4 741	6 435	4 440	3 374	3 029	2 150	2 919	2 014	1 530
Landing gear	933	828	1 315	1 155	1 141	423	376	596	524	518
Nacelle and strut	418	508	725	552	549	190	230	329	250	249
Rotor			3 873	3 719			–	1 757	1 687	–
Total structure	13 156	8 164	12 348	9 866	7 612	5 968	3 703	5 601	4 475	3 453
Engine	1 857	1 694	940	738	894	842	768	426	335	406
Engine accessories	188	185	295	208	318	85	84	134	94	144
Engine systems	357	355	483	371	85	162	161	219	168	38
Thrust reverser	130	161				59	73	–	–	–
Air ducting system	514	383				233	174	–	–	–
Drive system			4 027	3 656	1 715	–	–	1 827	1 658	778
Propeller installation					2 168	–	–	–	–	983
Total propulsion group	3 046	2 778	5 745	4 973	5 180	1 382	1 260	2 606	2 256	2 350
Instruments	424	336	265	211	210	192	152	120	96	95
Surface controls	625	496	1 973	1 948	2 683	284	225	895	884	1 217
Hydraulics	300	213	245	184	185	136	97	111	83	84
Pneumatics	138	117				63	53	–	–	–
Electrical	1 087	761	775	543	545	493	345	352	246	247
Electronics	691	432	750	490	490	313	196	340	222	222
Flight provisions	468	375	220	176	175	212	170	100	80	79
Passenger accommodations	2 706	2 385	2 275	2 025	2 025	1 227	1 082	1 032	918	918
Misc accommodations	95	95	1 198	926		43	43	543	420	
Emergency equipment	81	70	135	135	135	37	32	61	61	61
Air conditioning	364	325	750	680	520	165	147	340	308	236
Anti-icing	108	96	70	60	85	49	44	32	27	39
Auxiliary power unit	0	0	0	0	0	0	0	0	0	0
Community noise abatement	354	337				161	153	–	-	
Total fixed equipment	7 441	6 038	8 656	7 378	7 053	3 375	2 739	3 926	3 347	3 199
Exterior paint	0	0	0	0	0	0	0	0	0	0
Options	0	0	0	0	0	0	0	0	0	0
Manufacturer's empty weight	23 643	16 980	26 749	22 217	19 845	10 724	7 702	12 133	10 078	9 002
Standard and operational items	517	517	520	520	520	235	235	236	236	236
Operational empty weight	24 160	17 497	27 269	22 737	20 365	10 959	7 937	12 369	10 314	9 238
Maximum zero fuel weight	33 960	27 927	37 269	32 737	30 365	15 404	12 668	16 905	14 850	13 774
Maximum taxi weight	37 188	29 977	41 000	35 650	32 597	16 837	13 598	18 598	16 171	14 786

TABLE 5-4.—WEIGHT SUMMARY—100-PASSENGER AIRCRAFT

Airplane components	1975 augmentor wing STOL (lb)	1985 augmentor wing STOL (lb)	1975 helicopter (lb)	1985 helicopter (lb)	1985 tilt-rotor VTOL (lb)	1975 augmentor wing STOL (kg)	1985 augmentor wing STOL (kg)	1975 helicopter (kg)	1985 helicopter (kg)	1985 tilt-rotor VTOL (kg)
Wing	7 142	2 514			4 105	3 240	1 140			1 862
Horizontal tail	927	449			875	420	204			397
Vertical tail	559	292				254	132			
Body	10 213	6 922	10 080	6 970	6 323	4 633	3 140	4 572	3 162	2 868
Landing gear	1 400	1 241	2 335	2 065	2 122	635	563	1 059	937	963
Nacelle and strut	780	924	1 267	980	918	354	419	575	445	416
Rotor			7 484	7 252				3 395	3 290	
Total structure	21 022	12 342	21 166	17 267	14 343	9 536	5 598	9 601	7 832	6 506
Engine	3 507	2 964	1 944	1 562	1 496	1 591	1 344	882	709	679
Engine accessories	220	217	546	372	532	100	98	248	168	241
Engine systems	467	464	661	492	151	212	210	300	223	68
Thrust reverser	257	320				117	145		-	
Air ducting system	655	488				297	221		-	-
Drive system			8 353	7 785	3 621			3 789	3 531	1 642
Propeller installation					4 264					1 934
Total propulsion group	5 107	4 452	11 504	10 211	10 064	2 307	2 019	5 218	4 631	4 565
Instruments	436	344	265	211	210	198	156	120	96	95
Surface controls	891	754	3 328	3 344	4 893	404	342	1 509	1 517	2 219
Hydraulics	348	243	265	199	200	158	110	120	90	91
Pneumatics	203	171				92	78		-	-
Electrical	1 087	761	875	612	615	493	345	397	278	279
Electronics	775	476	750	490	490	352	216	340	222	222
Flight provisions	501	401	220	176	175	227	182	100	80	79
Passenger accommodations	3 974	3 498	4 500	4 000	4 000	1 803	1 587	2 041	1 814	1 814
Misc accommodations	179	179	3 128	2 026		81	81	1 419	919	-
Emergency equipment	118	99	135	135	135	54	45	61	61	61
Air conditioning	477	429	1 500	1 353	970	216	195	680	614	440
Anti-icing	116	100	70	60	85	53	45	32	27	39
Auxiliary power unit	0	0	0	0	0	0	0	0	0	0
Community noise abatement	575	546				261	248			
Total fixed equipment	9 681	8 000	15 036	12 606	11 773	4 391	3 629	6 820	5 718	5 340
Exterior paint	0	0	0	0	0	0	0	0	0	0
Options	0	0	0	0	0	0	0	0	0	0
Manufacturer's empty weight	35 810	24 794	47 706	40 084	36 180	16 243	11 247	21 639	18 182	16 411
Standard and operational items	599	599	520	520	520	272	272	236	236	236
Operational empty weight	36 408	25 393	48 226	40 604	36 700	16 515	11 518	21 875	18 418	16 647
Maximum zero fuel weight	55 408	44 393	67 826	60 204	56 700	25 133	20 137	30 766	27 309	25 719
Maximum taxi weight	60 350	48 580	75 000	66 000	60 636	27 375	22 036	34 020	29 938	27 504

TABLE 5-5.--AIRCRAFT ACQUISITION COSTS

Aircraft type	Passenger capacity	1975 technology, 1970 dollars in millions			1985 technology, 1970 dollars in millions		
		Airframe[a]	Engines	Total	Airframe[a]	Engines	Total
Augmentor wing STOL	49	1.121	0.438	1.559	1.140	0.430	1.570
	95	1.423	0.545	1.968	1.432	0.531	1.963
	153	1.787	0.685	2.472	1.783	0.663	2.446
Helicopter VTOL	50	1.449	0.228	1.677	1.449	0.211	1.660
	98	1.992	0.355	2.347	1.992	0.331	2.323
	150	2.440	0.452	2.892	2.440	0.441	2.881
Tilt rotor VTOL	50				1.323	0.239	2.481
	100			–	1.946	0.377	2.323
	150			–	2.481	0.488	2.969

[a] Includes S305 000 for electronics in all cases

TABLE 5-6.—IOC COEFFICIENT SUMMARY

Cost category	Parameter						
	Nodes	Departures, millions	Gates	Miles, millions	Fleet size	(Seats) (dep), millions	Seat miles, millions
Total aircraft servicing cost (TASC)	0.058705		0.097842		0.002446		
Traffic servicing cost (TTSC)	0.042020		0.001013 + (0.00004052) (seats)				
Servicing and administration cost (TSAC)	0.015255		0.013868		0.000347		
General and administration cost (TGAC)	0.0286		0.026		0.00065		
Ground facility cost (TGFC)		1.717		0.0151		0.0233	0.0000792
Passenger liability expense (PLE)						(0.125)LF	
Totals	0.144580	1.717	0.138723 + (0.00004052) (seats)	0.0151	0.003443	0.0233 + (0.125)LF	0.0000792

IOC = 0.14458 (nodes) + 1.717 (departures) + 0.0151 (miles flown)
+ 0.138723 (gates) + 0.00004052 (gates)(seats) + 0.003443 (fleet)
+ 0.0233 (departures)(seats) + 0.125 (departures)(seats)(LF)
+ 0.0000792 (seats)(miles flown)
Millions of dollars per year

TABLE 5-7.—IOC COMPARISON TABLE

Class of service[a]	Passengers, millions	Departures, millions	RPM, billions	IOC, millions	IOC unit costs		
					S/pass	S/dep	S RPM
Domestic	116.671	3.142	90.393	2417.535	20.72	769.0	0.0267
Local	23.388	1.594	6.473	266.835	11.41	167.0	0.0412
Helicopter	0.418	0.064	0.011	4.4	10.52	69.0	0.4000
Intraurban	15.245	0.688	0.356	14.941	0.95	21.0	0.0420

[a]Data for the STOL network is from the base case Data for domestic, local, and helicopter service is from 1969 CAB handbook.

TABLE 5-8.—1980 AIR TERMINAL COST SUMMARY

STOLport				VTOLports			
Zone no.	Terminal type	No. of gates	Cost[b]	Zone no.	Terminal type	No. of gates	Cost[b]
1	C	7	87.9	1	F	6	35.0
2	A	2	37.6	2	F	2	15.7
3	C	3	81.0	3	F	3	19.0
4	B	1	34.3	4	F	2	15.0
5	B	1	34.3	5	G	3	12.6
6	A	3	15.2	6	E	2	7.5
7	A	3	14.4	7	E	2	7.4
8	B	1	14.6	8	E	1	6.2
9	A	2	12.8	9	E	2	7.3
10	-	–	–	10	E	1	6.2
11	A	2	14.6	11	+	2	7.3
12	A	1	11.2	12	E	1	6.1
13	-	–	–	13	E	1	6.2
14	B	2	15.9	14	E	2	7.4
15	A	3	17.0	15	E	3	9.0
16	B	2	27.9	16	F	3	17.4
17	B	2	29.2	16	E	2	9.0
18	B	1	19.3	17	E	1	6.9
20	A	2	13.7	18	E	1	6.4
21	A	1	11.9	20	E	2	7.5
22	B	1	16.7	21	E	1	6.2
24	A	1	12.5	22	E	1	6.3
26	A	1	11.7	24	E	1	6.2
29	A	2	13.7	26	E	1	6.2
30	B	2	24.2	29	E	1	6.3
		Total	609.1	30	E	2	8.0
						Total	255.3

[a]49-passenger airplane

[b]1980 costs in 1970 dollars in millions

TABLE 5-9.—BASE CASE CHARACTERISTICS

Daily passenger demand	60 105	
Daily passengers carried	48 551	
Daily revenue passenger statute miles (kilometers)	1 135 690	(1 827 320)
Daily revenue flights	2 190	
Daily ferry flights	102	
Total daily flights	2 292	
Average load factor	0.447	
Average passenger trip distance (statute miles)(kilometers)	23.4	(37.6)
Aircraft required	73	
Average utilization (hrs/day)	4.22	
Number of gates	48	
Number of terminals	24	
Number of links	65	
Daily DOC (no depreciation)	$114 250	
Daily IOC	$47 586	
Daily TOC	$161 836	
Daily revenue	$174 890	
Daily operating profit	$13 054	

TABLE 5-10.—BARTD COMPARISON

System characteristics	BARTD 1975 estimate	Intraurban 1980 market	
		STOL	Helicopter
Passengers (daily)	200 000	48 551	52 483
Route system, miles (kilometers)	75 (121)	1550 (2494)	1550 (2494)
Stations/ports	33	24	24
Links	528	65	65
Daily revenue passenger miles (kilometers)	1 760 000 (2 830 000)	1 140 000 (1 830 000)	1 105 000 (1 780 000)
Average trip length, miles (kilometers)	9 14.5	23 37	21 34
Initial investment	$1 300 000 000	745 000 000	412 000 000
Annual revenue	$25 000 000	55 000 000	59 000 000
Annual cost to taxpayer	$100 000 000	48 000 000	35 000 000
Average fare	$0.45	$3.60	$3.56
Loss/passenger	$1.70	$4.05	$2.42
Total cost per passenger	$2.15	$7.65	$5.98
Total cost per passenger mile	$0.24	$0.29	$0.27

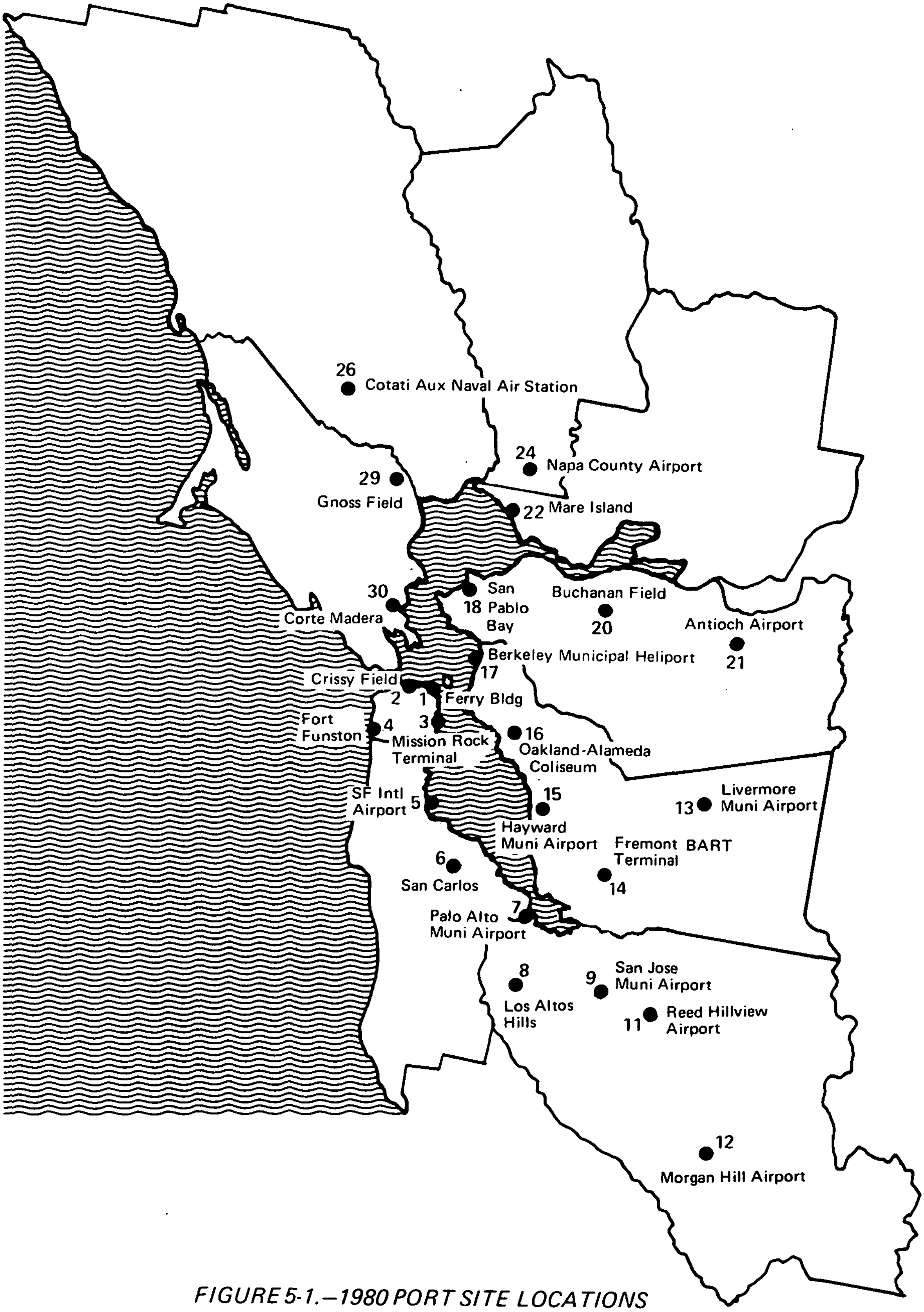


FIGURE 5-1.—1980 PORT SITE LOCATIONS

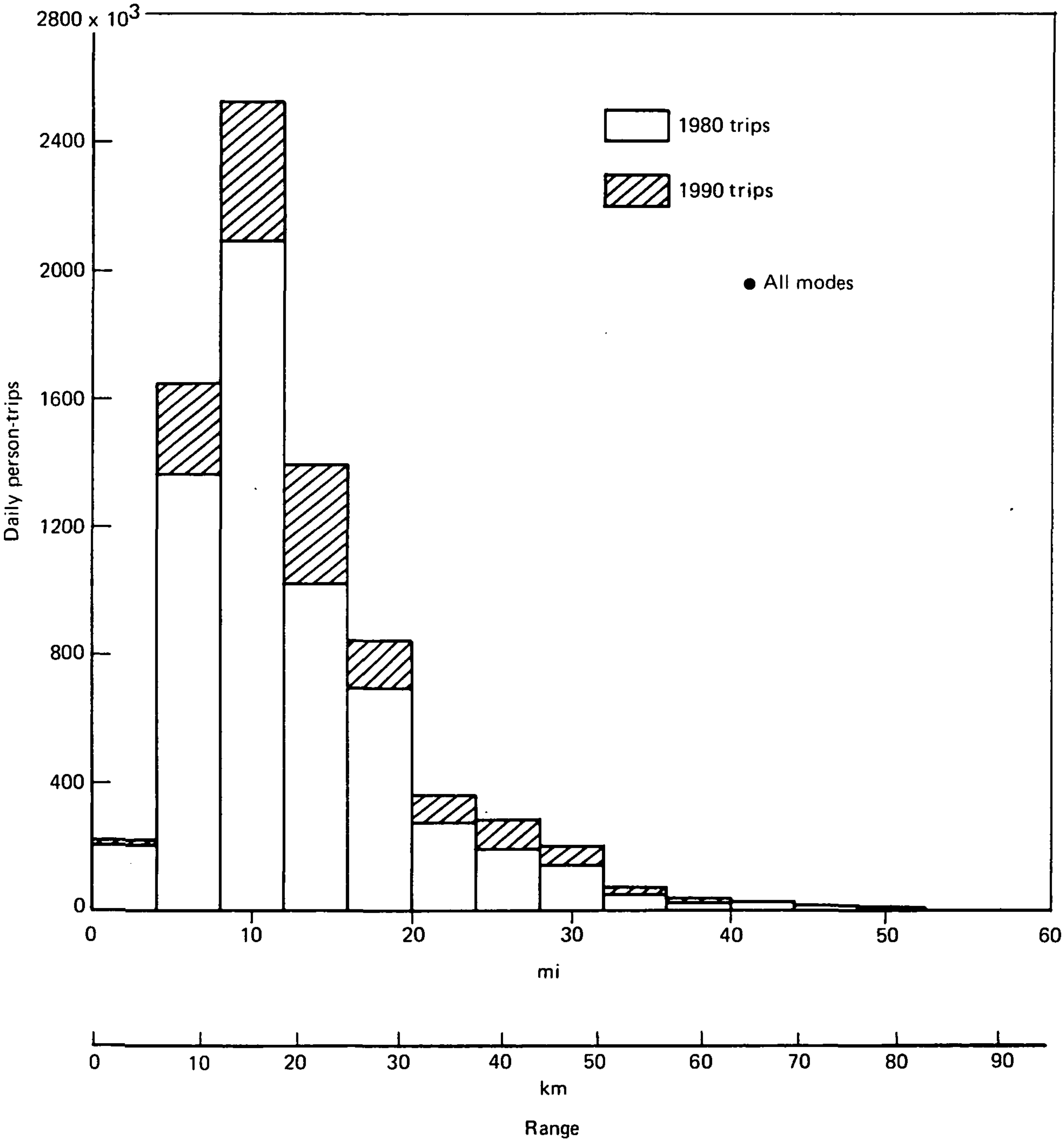


FIGURE 5-2.—TOTAL DAILY PERSON-TRIPS BETWEEN TERMINAL AREAS

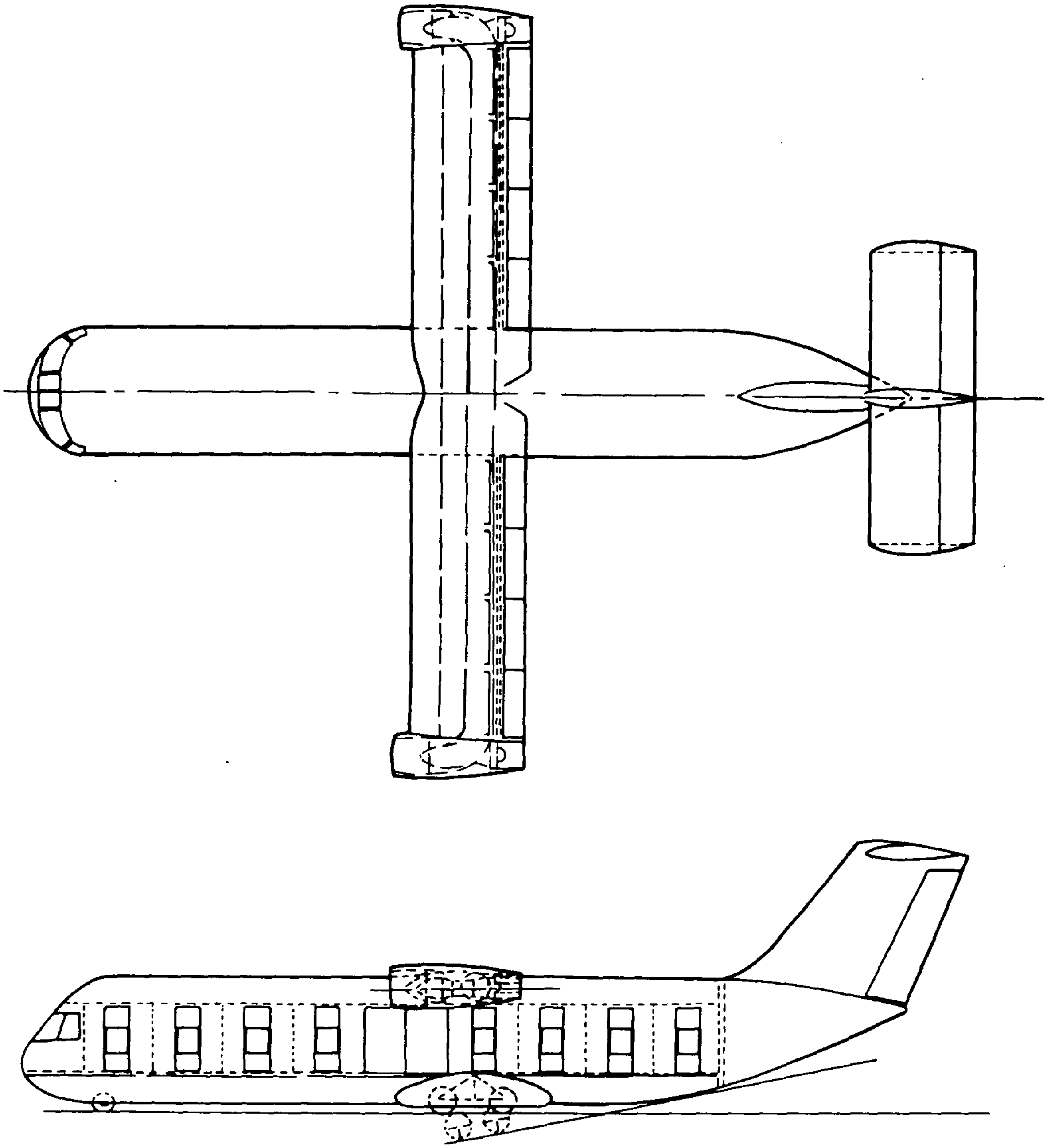


FIGURE 5-3.–1975 AUGMENTOR WING STOL GENERAL ARRANGEMENT, 95 PASSENGERS

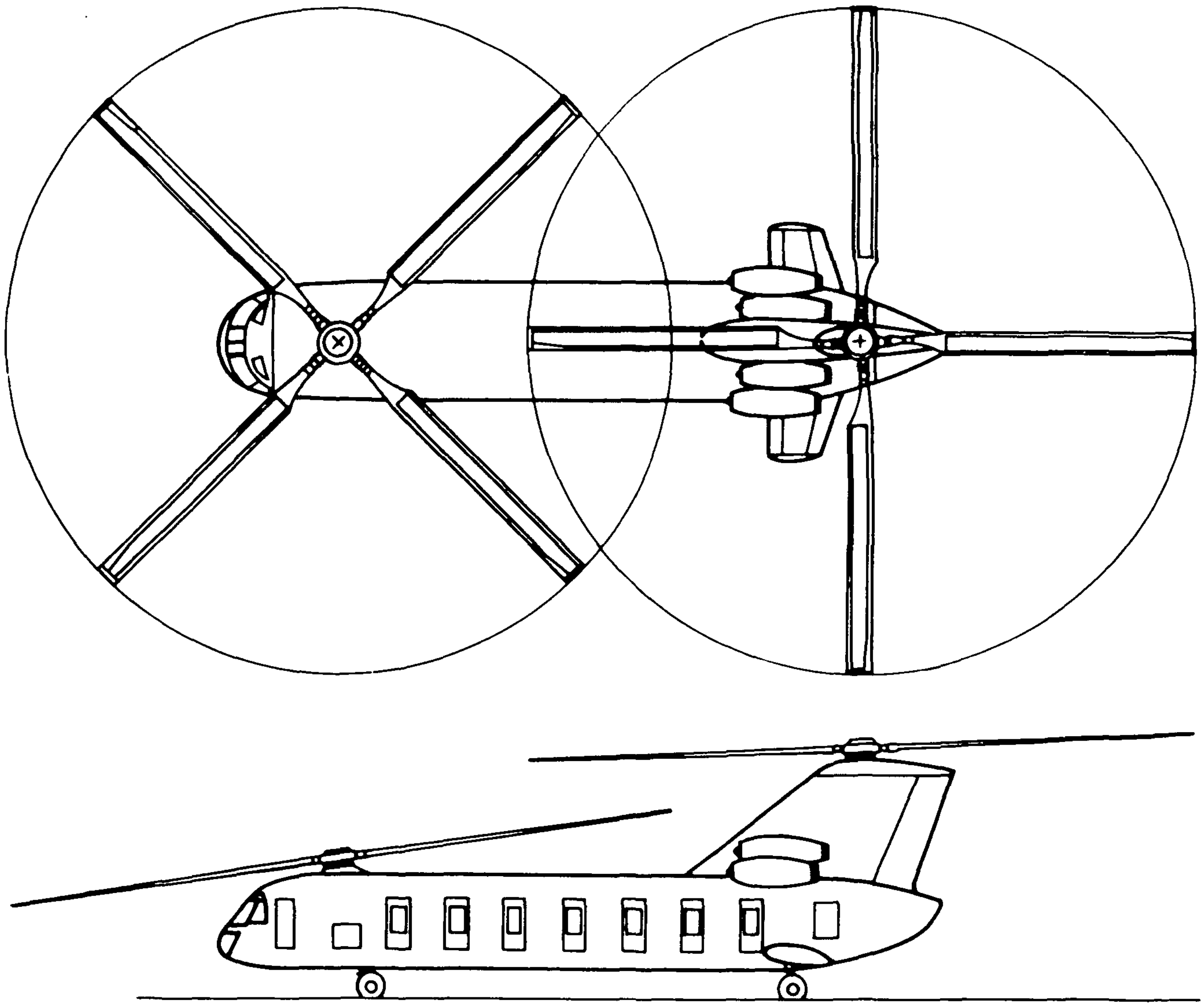


FIGURE 5-4.—1975 HELICOPTER GENERAL ARRANGEMENT—98 PASSENGERS

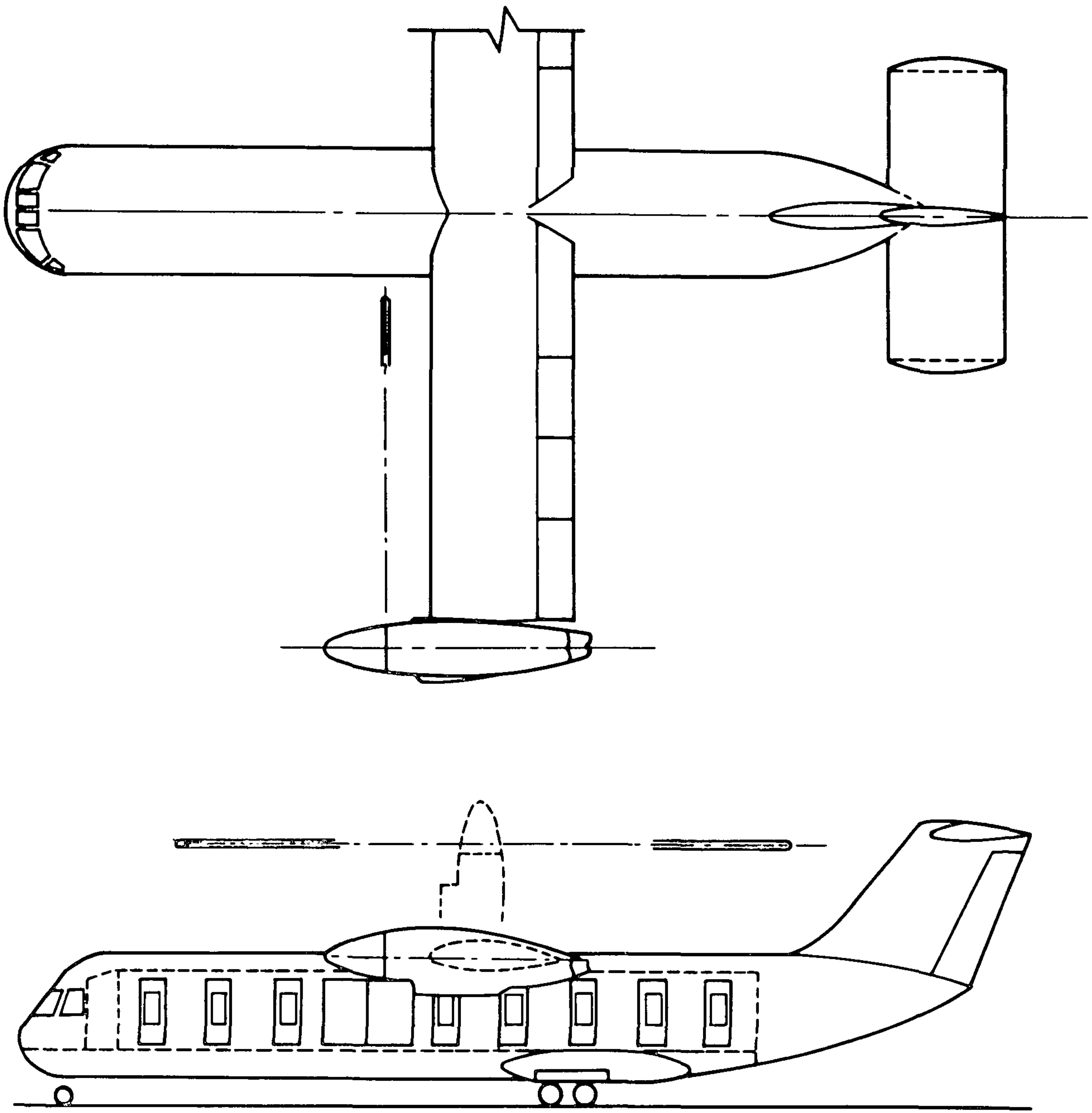


FIGURE 5-5.–1985 TILT ROTOR GENERAL ARRANGEMENT, 100 PASSENGERS

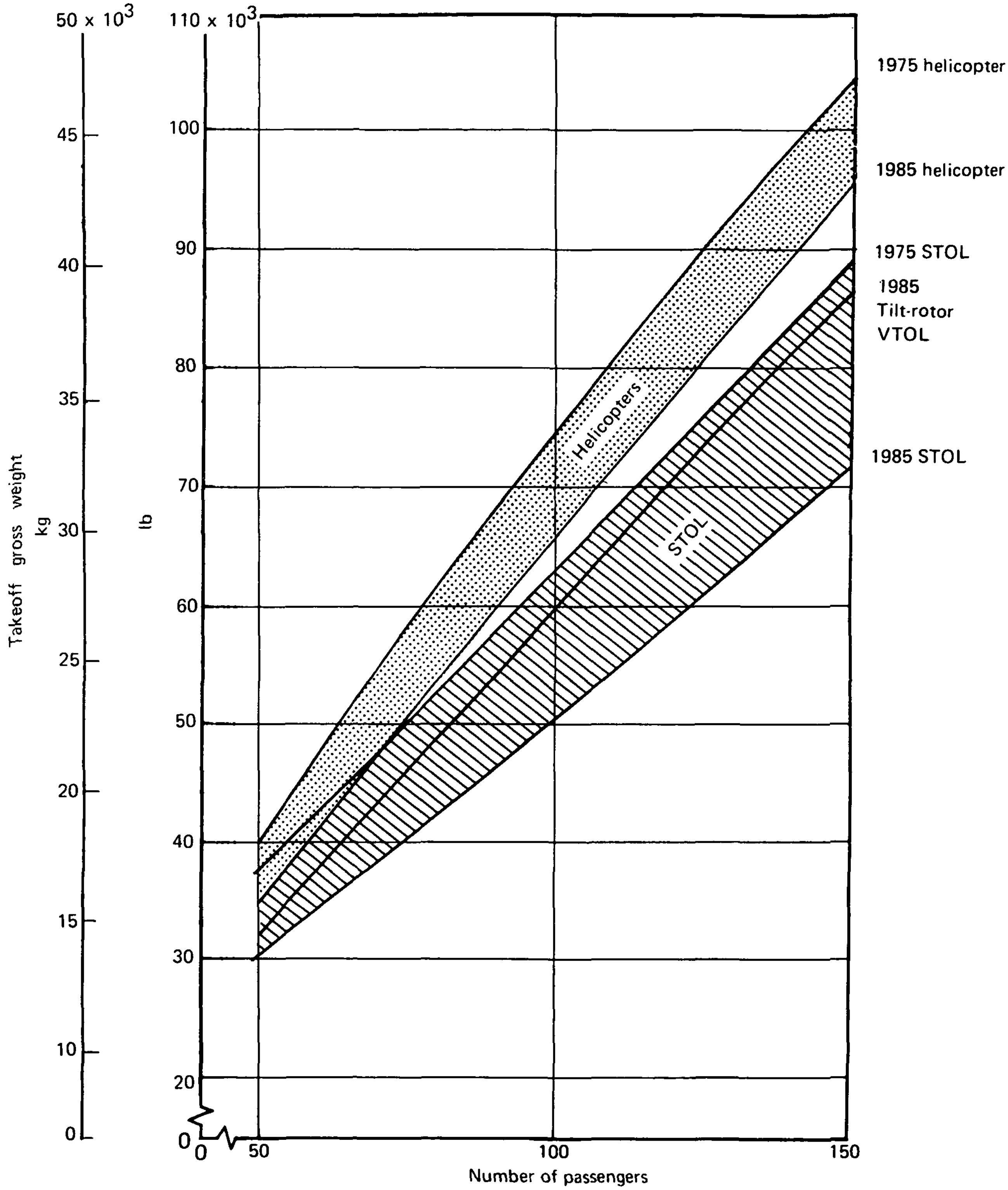


FIGURE 5-6.–TAKEOFF GROSS WEIGHT–BASELINE AIRCRAFT

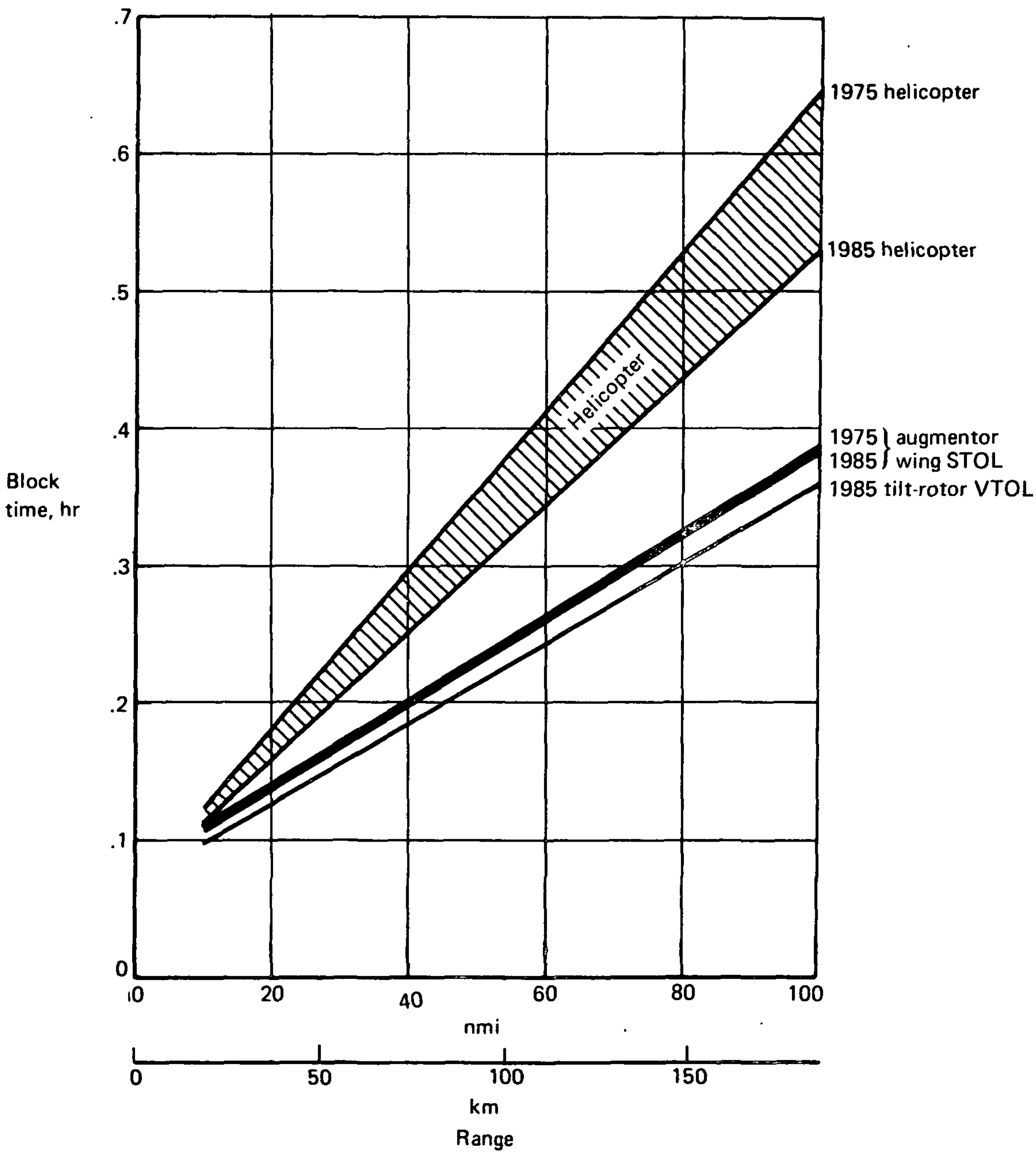


FIGURE 5-7.—BLOCK TIME FOR BASELINE AIRPLANES—100 PASSENGERS

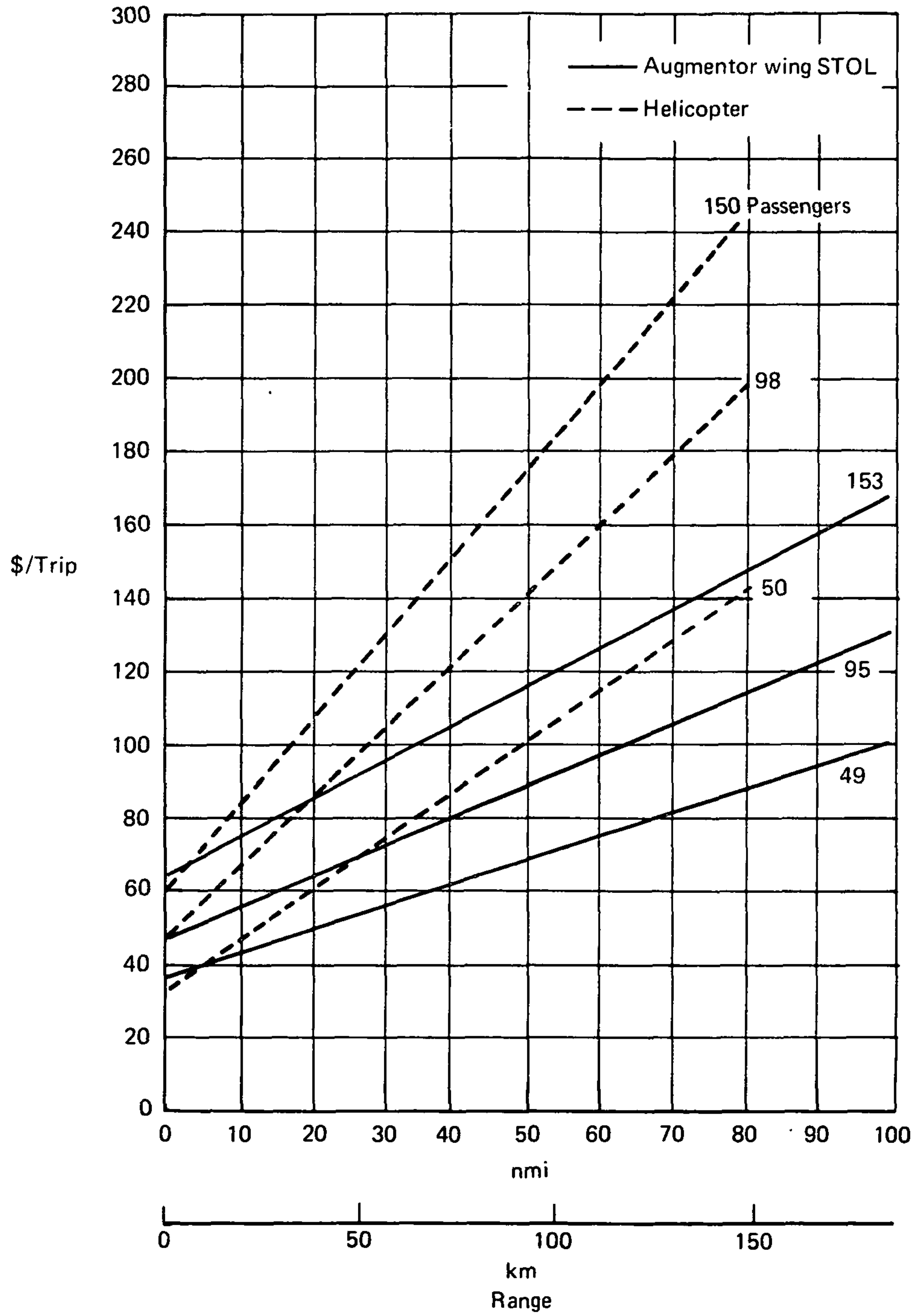


FIGURE 5-8.—CASH DIRECT OPERATING COST MINUS DEPRECIATION (1975)

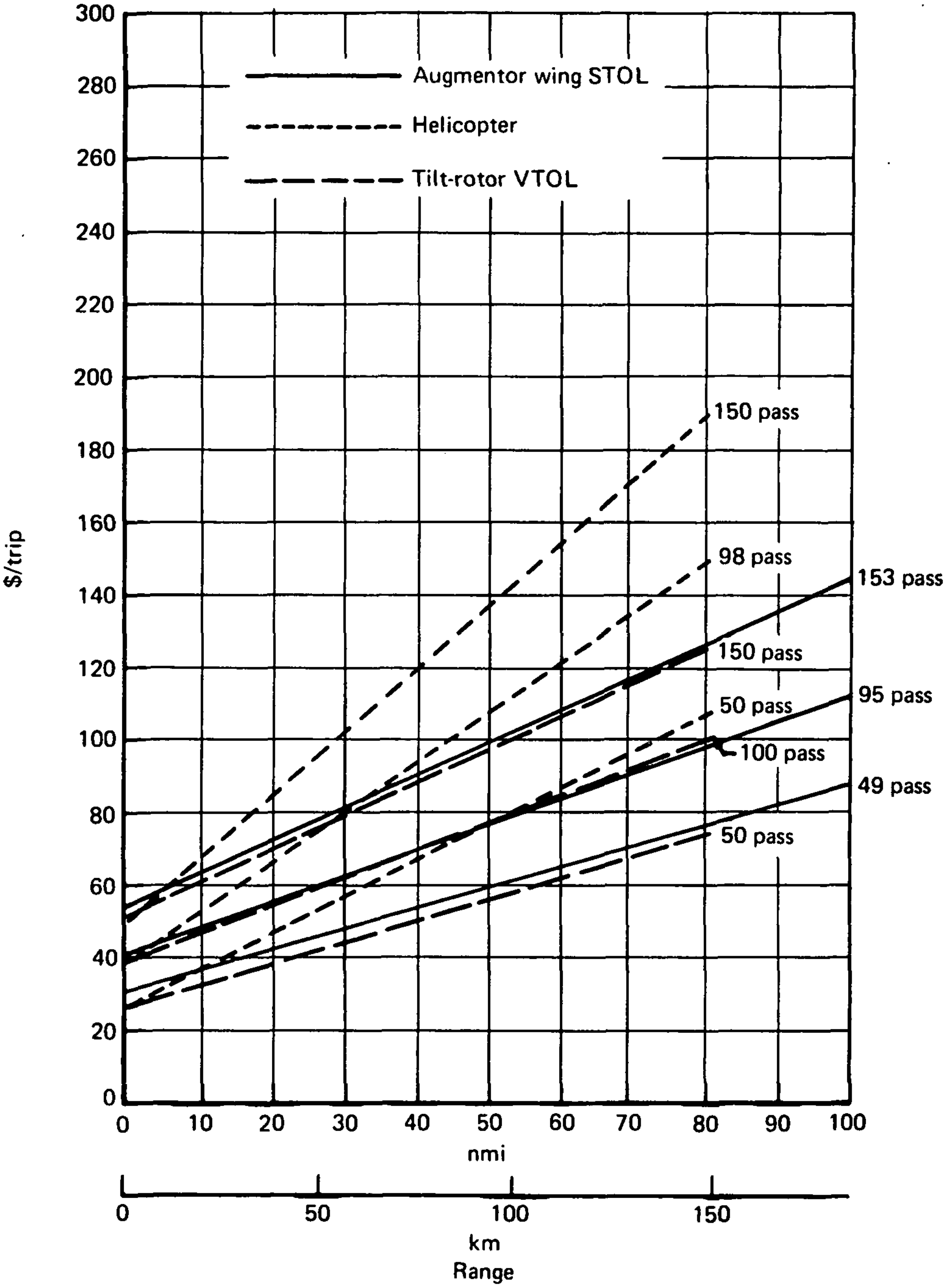


FIGURE 5-9.—CASH DIRECT OPERATING COST MINUS DEPRECIATION (1985)

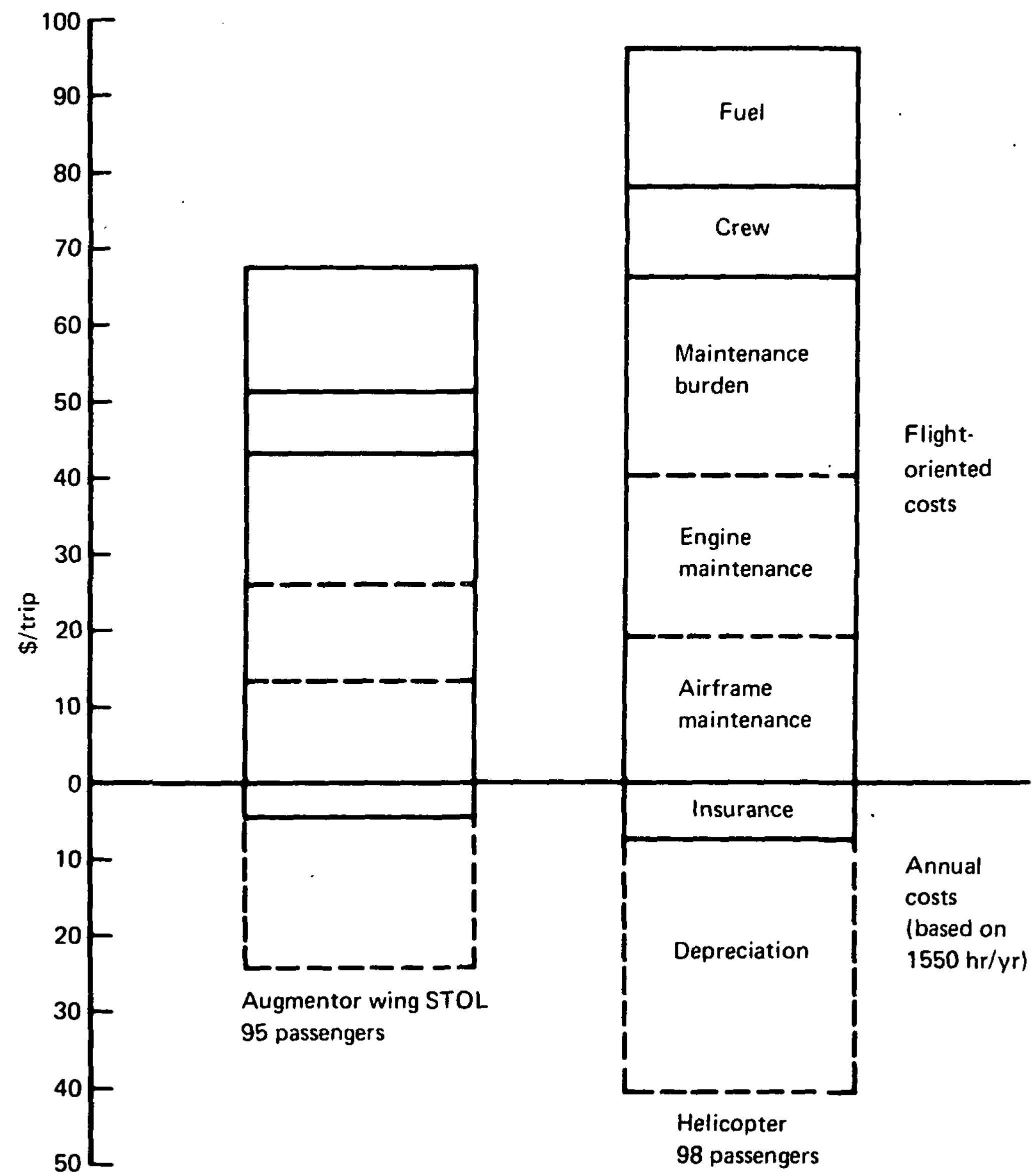


FIGURE 5-10.–CASH DIRECT OPERATING COST PLUS DEPRECIATION–30-NMI (55.5 KM) TRIP (1975)

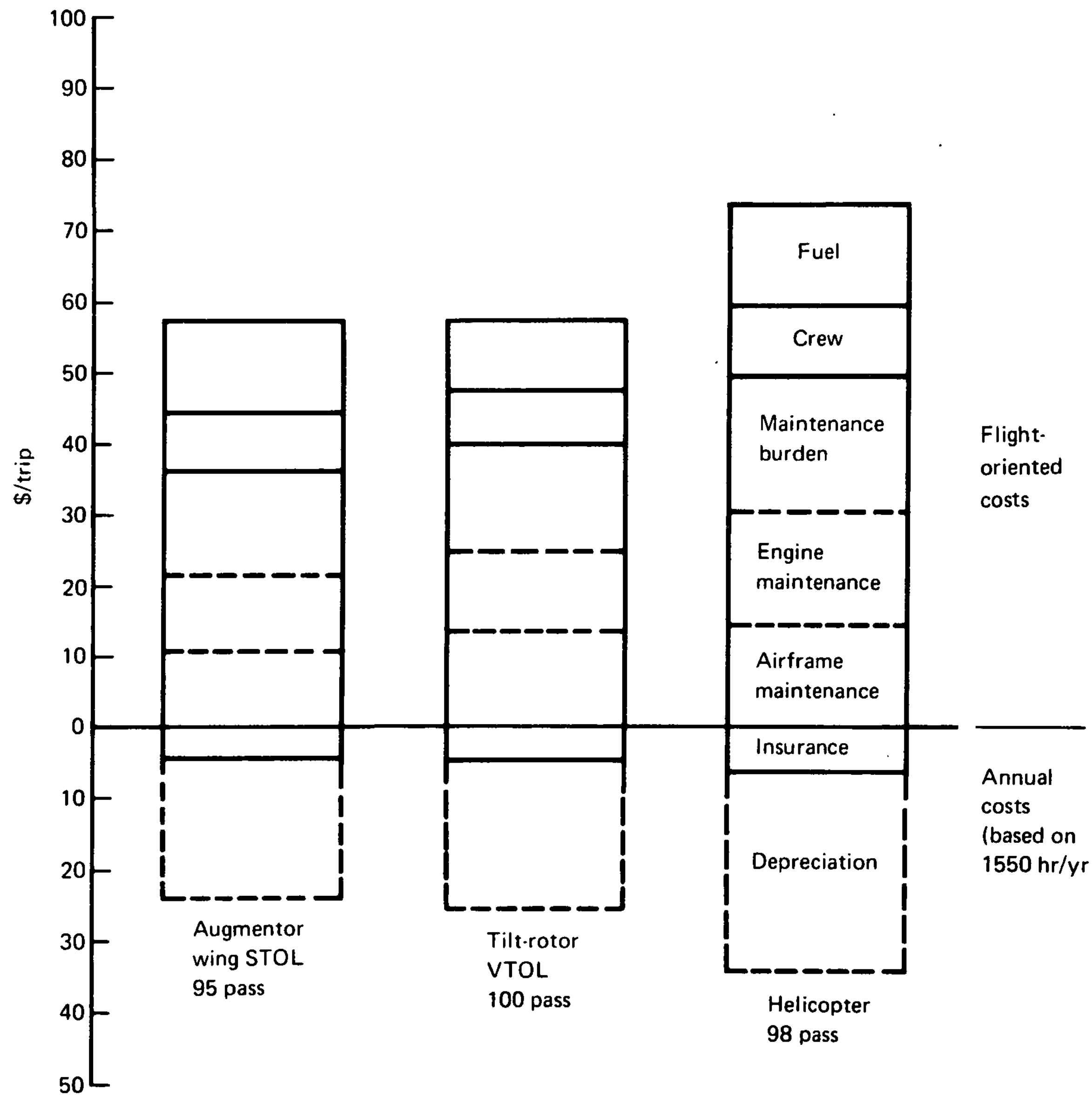


FIGURE 5-11.—CASH DIRECT OPERATING COST PLUS DEPRECIATION—30-NMI (55.5 KM) TRIP (1985)

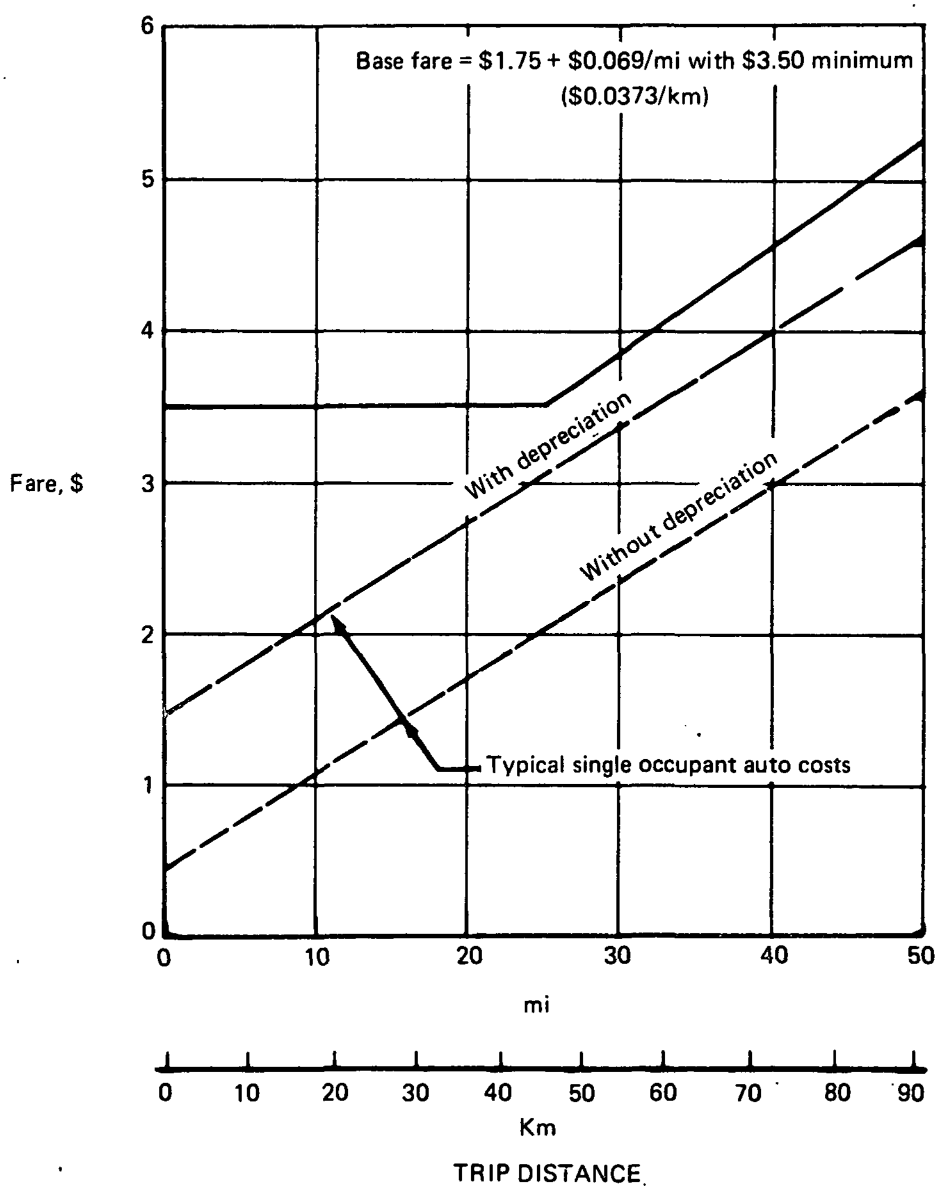


FIGURE 5-12.—BASE FARE LEVEL

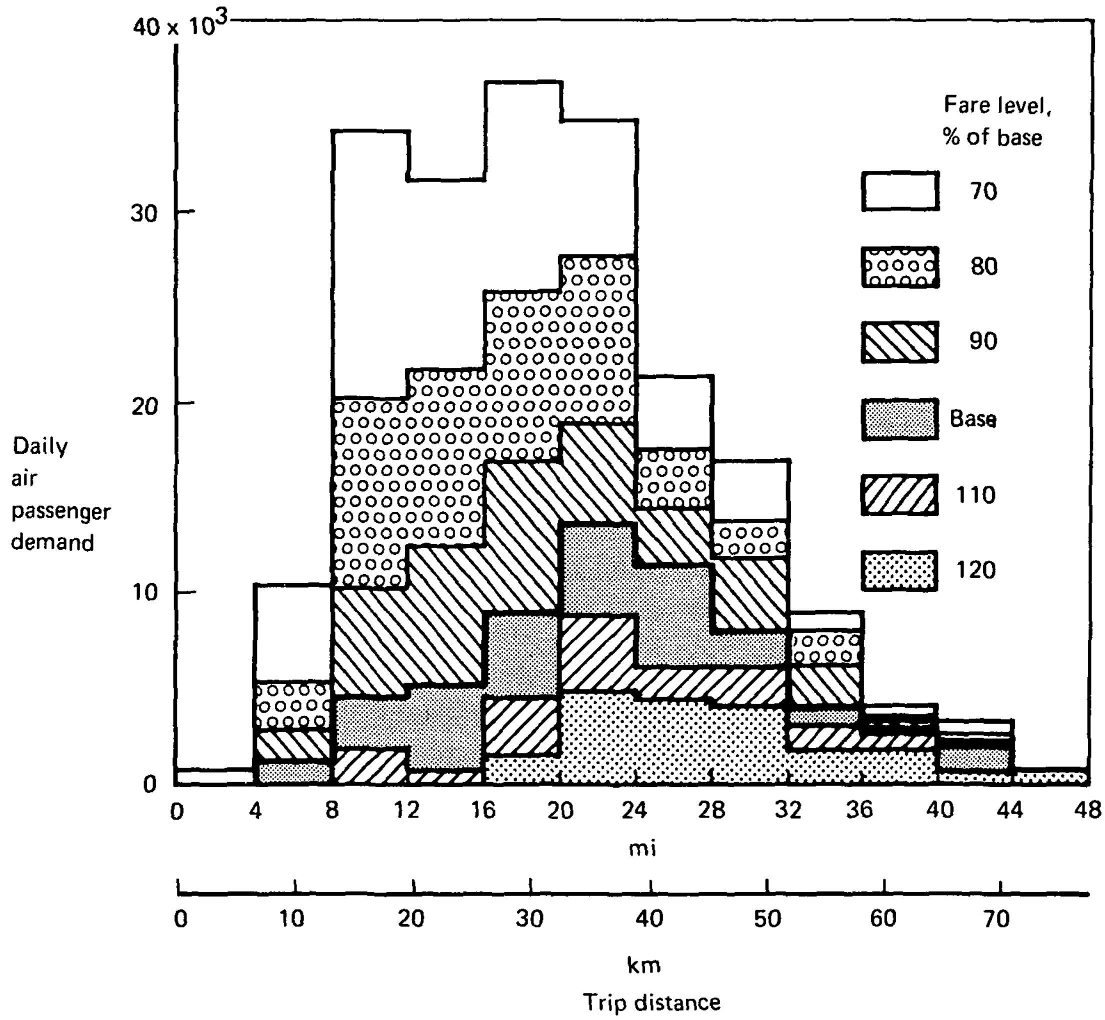


FIGURE 5-13.—TRAVEL DEMAND SENSITIVITY TO FARE
1975 STOL, 1980 MARKET

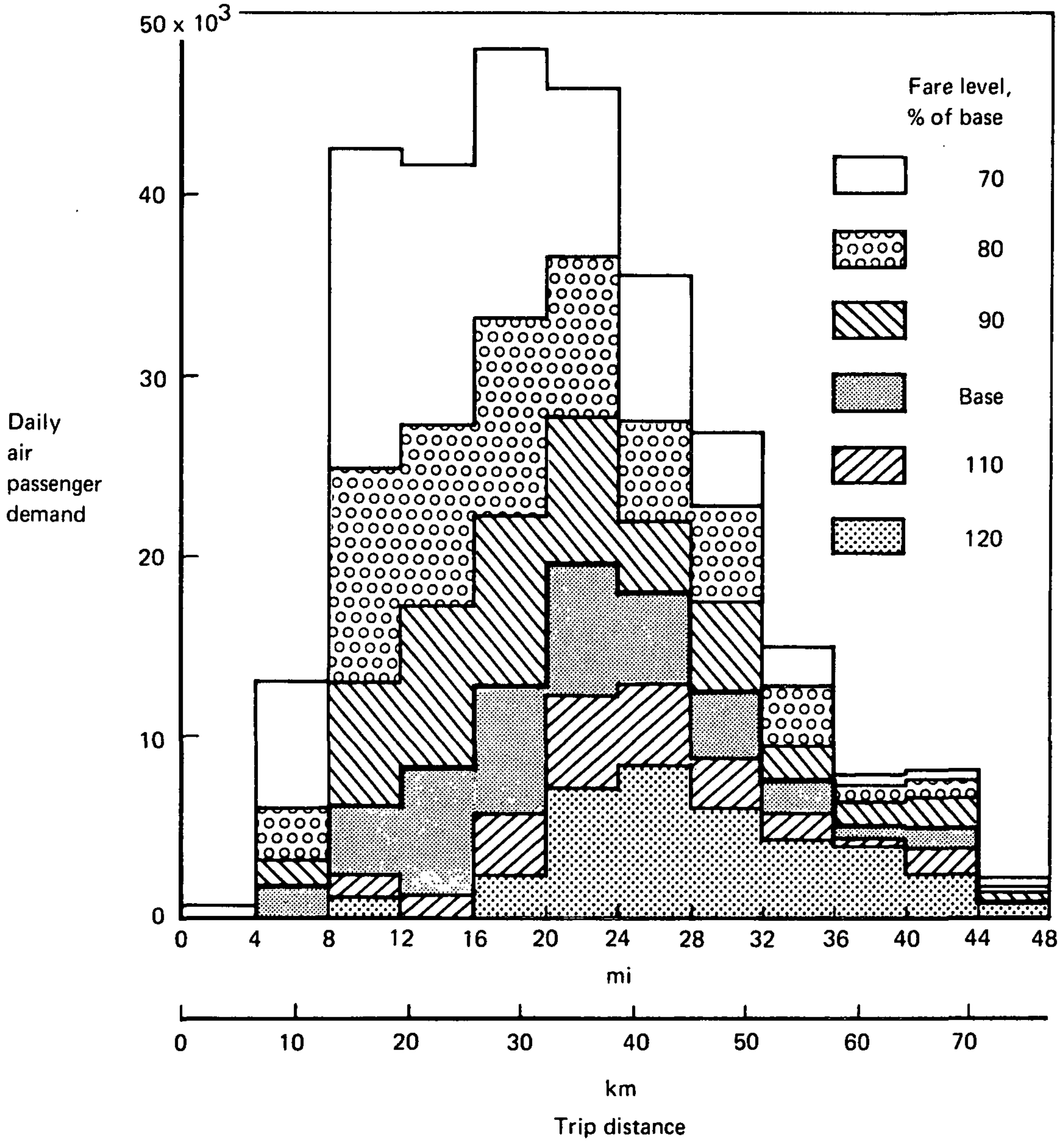
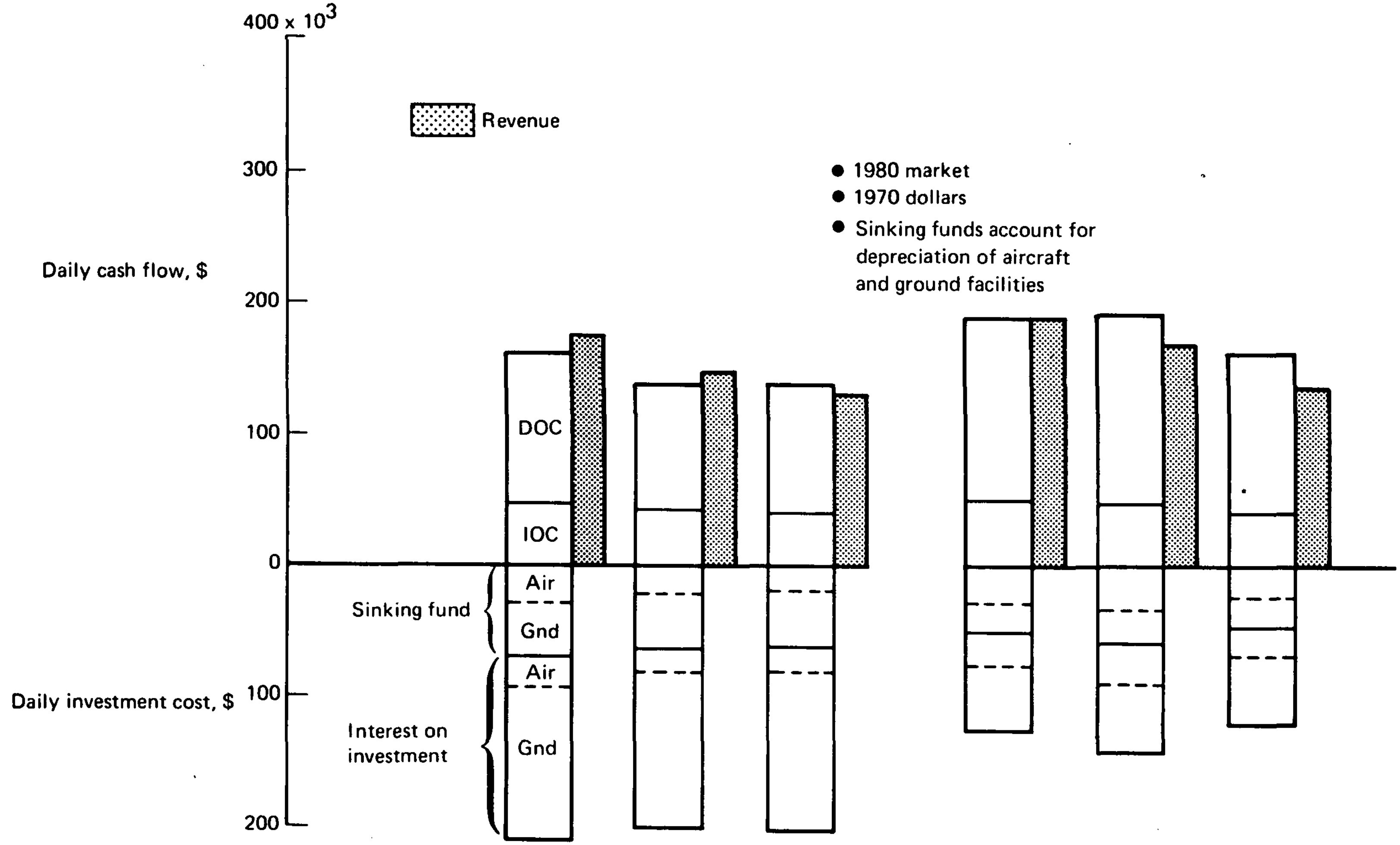
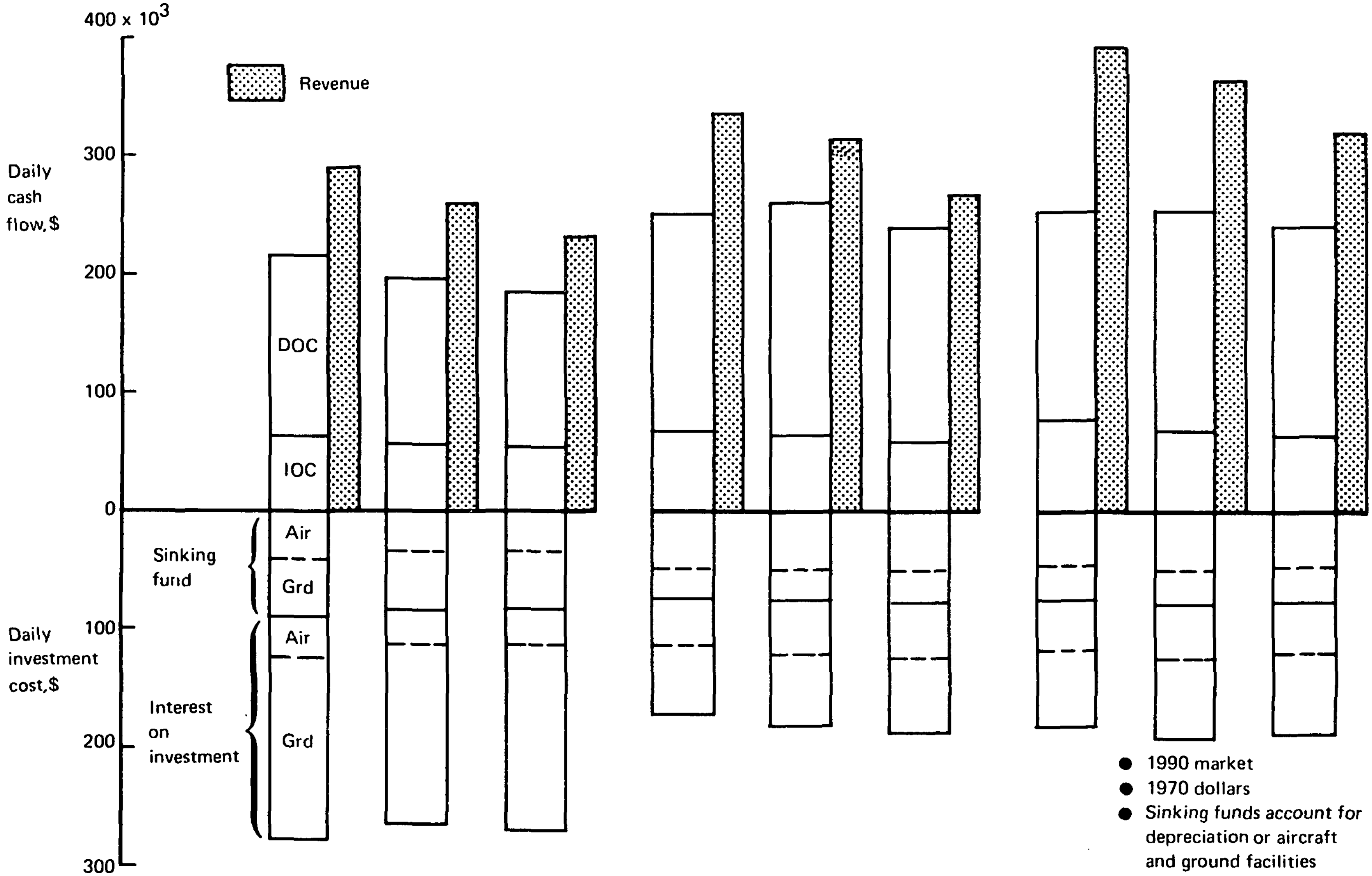


FIGURE 5-14.–TRAVEL DEMAND SENSITIVITY TO FARE
1985 STOL, 1990 MARKET



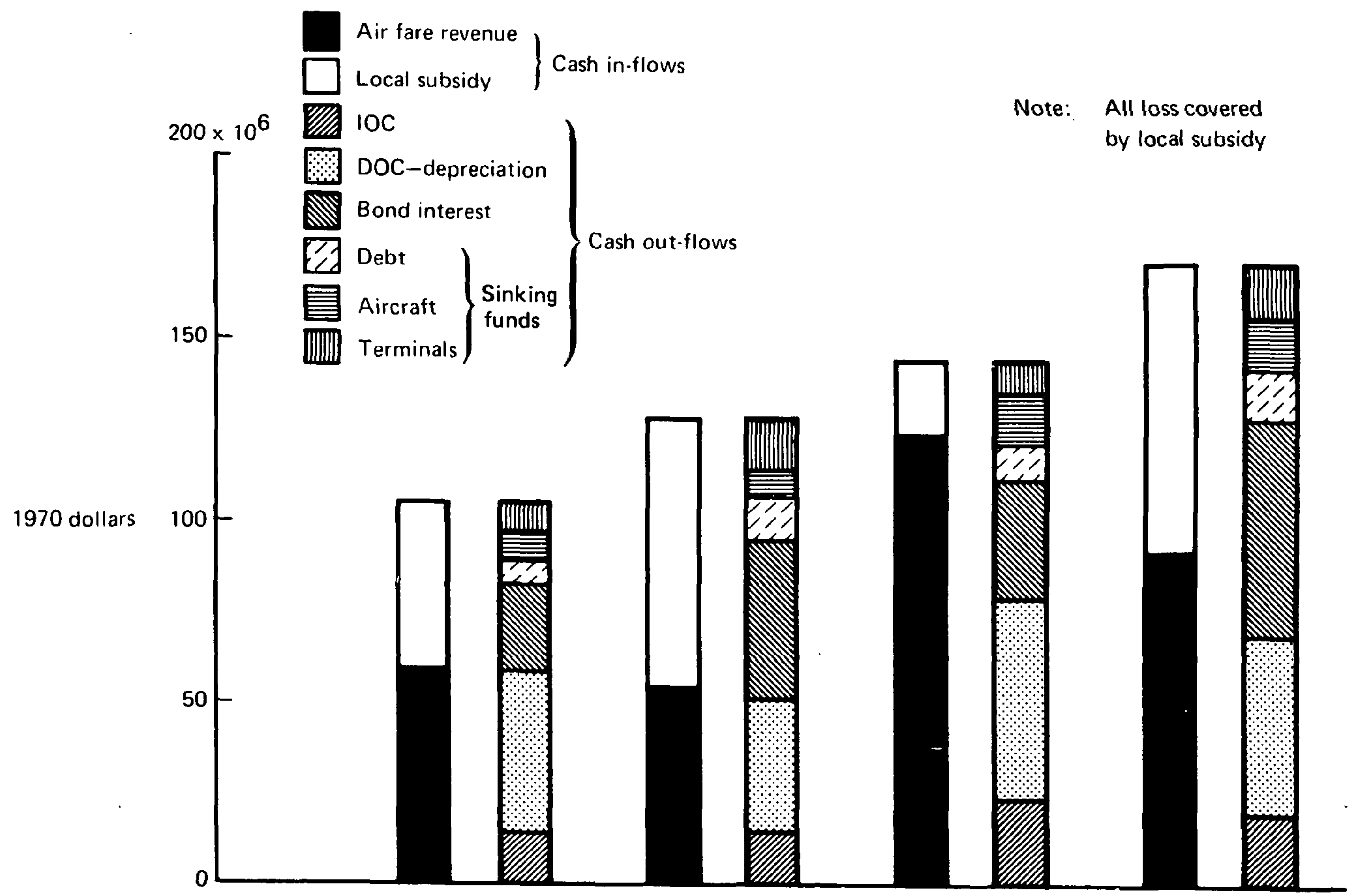
Vehicle	Augmentor wing STOL			Helicopter		
Passengers	49	95	153	50	98	150
Net loss per day	$194 000	$190 000	$208 000	$128 000	$163 000	$147 000
Loss per passenger	$4.05	$4.70	$5.80	$2.42	$3.55	$3.85

FIGURE 5-15.—CONCEPT ECONOMIC COMPARISON—1975 AIRCRAFT



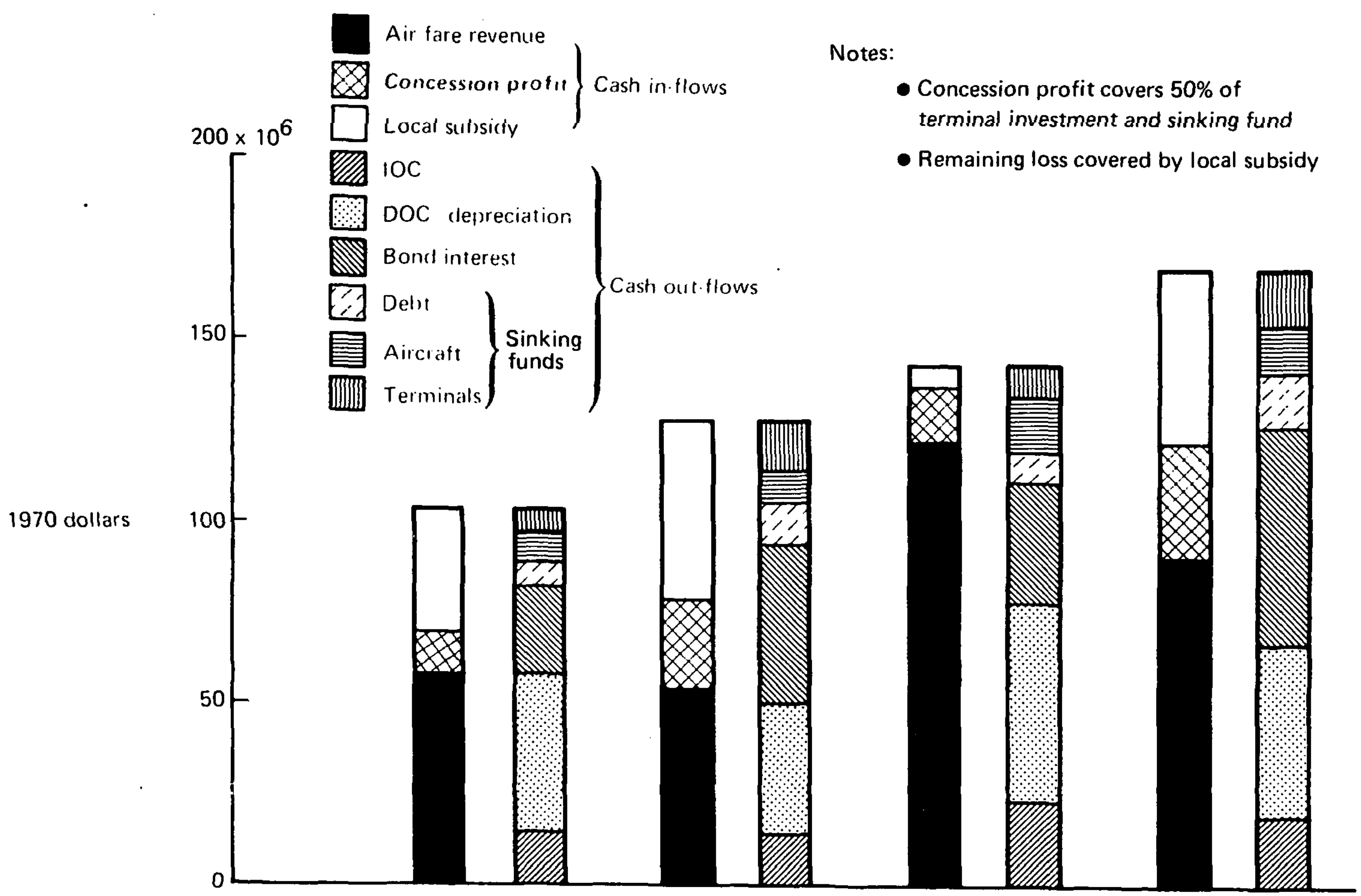
Vehicle	STOL-augmentor			VTOL-helicopter			VTOL-tilt rotor		
Passengers	49	95	153	50	98	150	50	100	150
Loss per passenger	\$2.65	\$3.00	\$3.35	\$1.05	\$1.35	\$1.95	\$.40	\$.80	\$1.25

FIGURE 5-16.—CONCEPT ECONOMIC COMPARISON—1985 AIRCRAFT



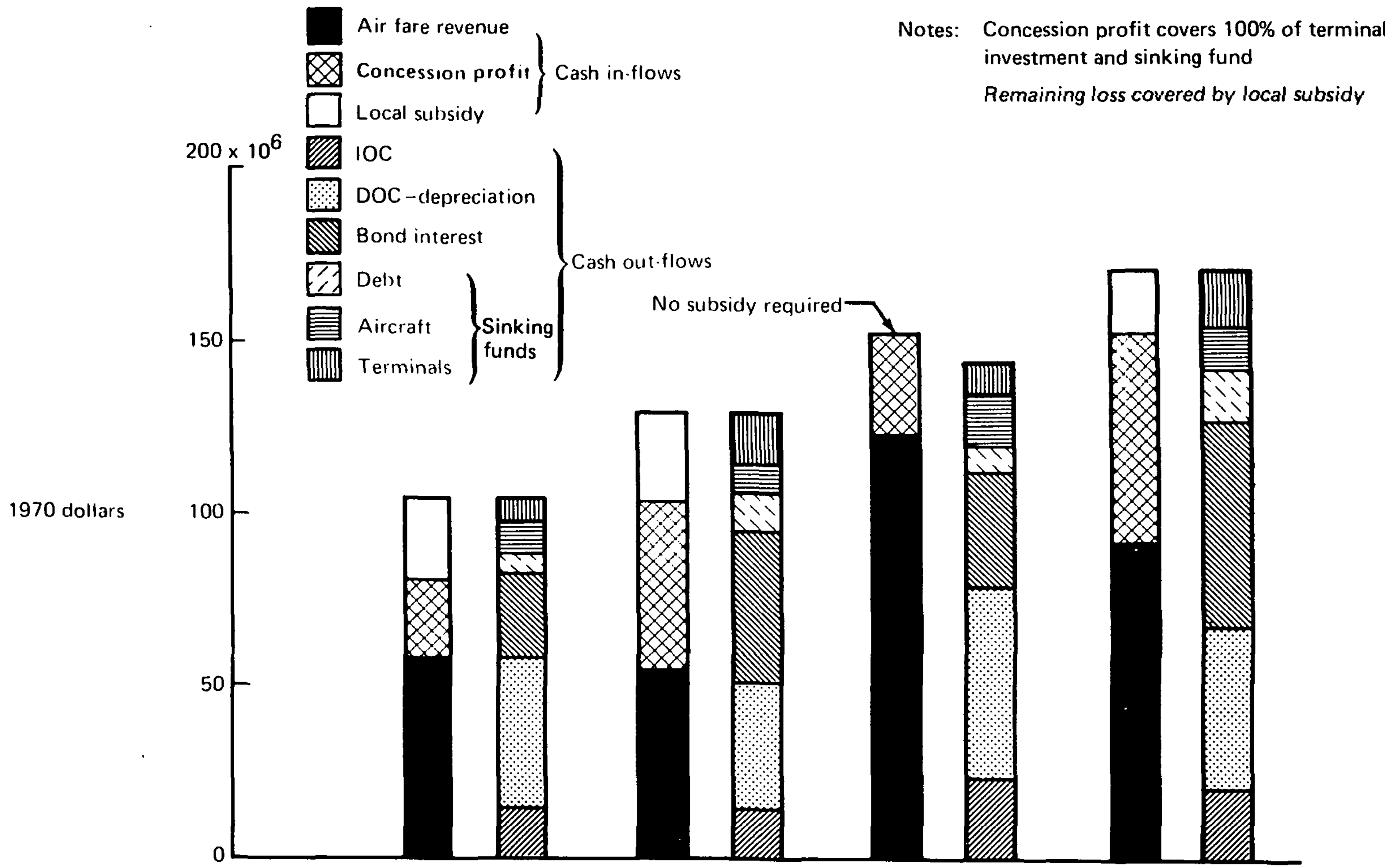
Vehicle	Helicopter	Augmentor wing STOL	Tilt-rotor VTOL	Augmentor wing STOL
Passengers	50	49	50	49
Technology	1975		1985	
Market	1980		1990	

FIGURE 5-17.—ANNUAL CASH FLOW A



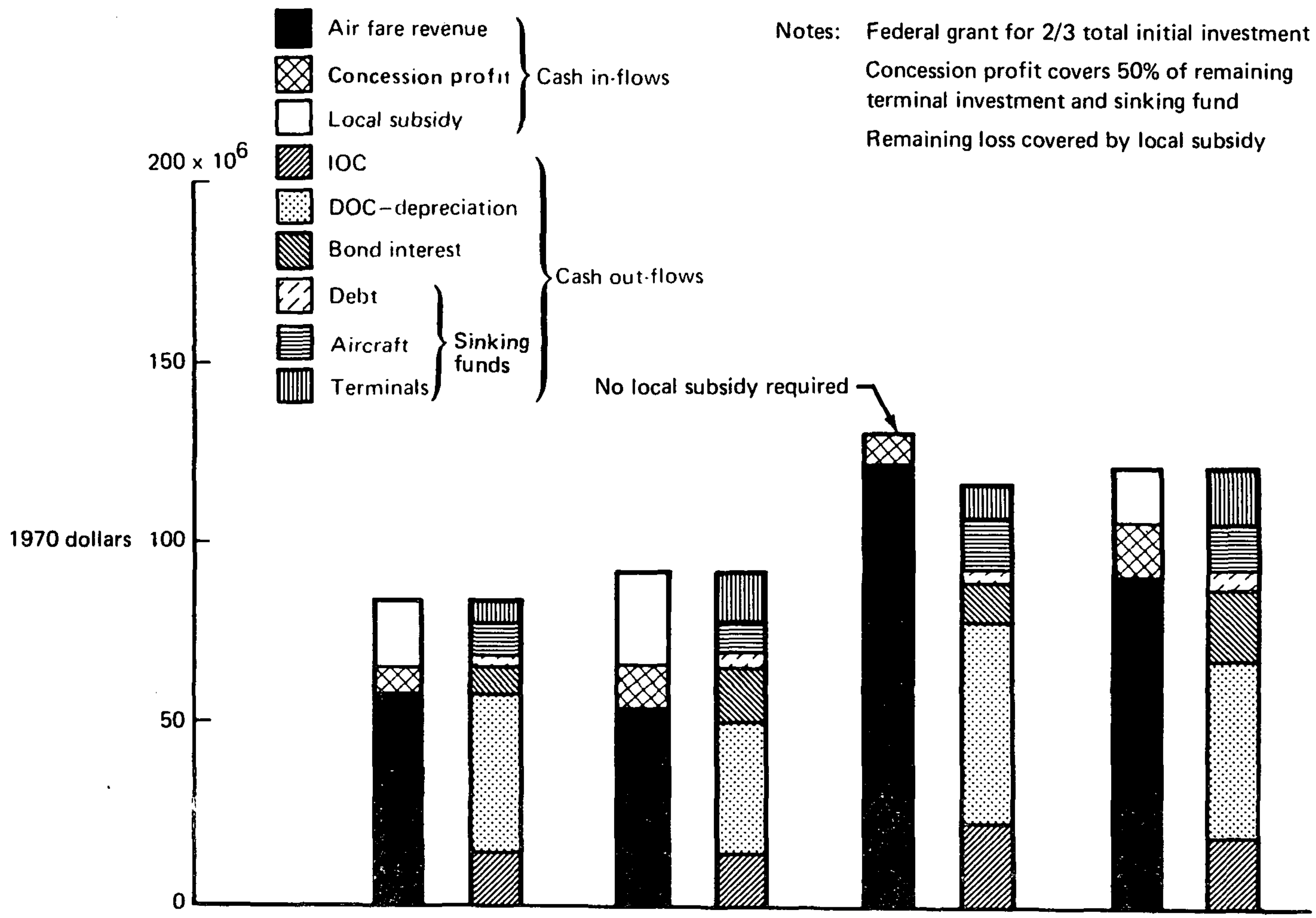
Vehicle	Helicopter	Augmentor wing STOL	Tilt-rotor VTOL	Augmentor wing STOL
Passengers	50	49	50	49
Technology	1975		1985	
Market	1980		1990	

FIGURE 5-18.—ANNUAL CASH FLOW B



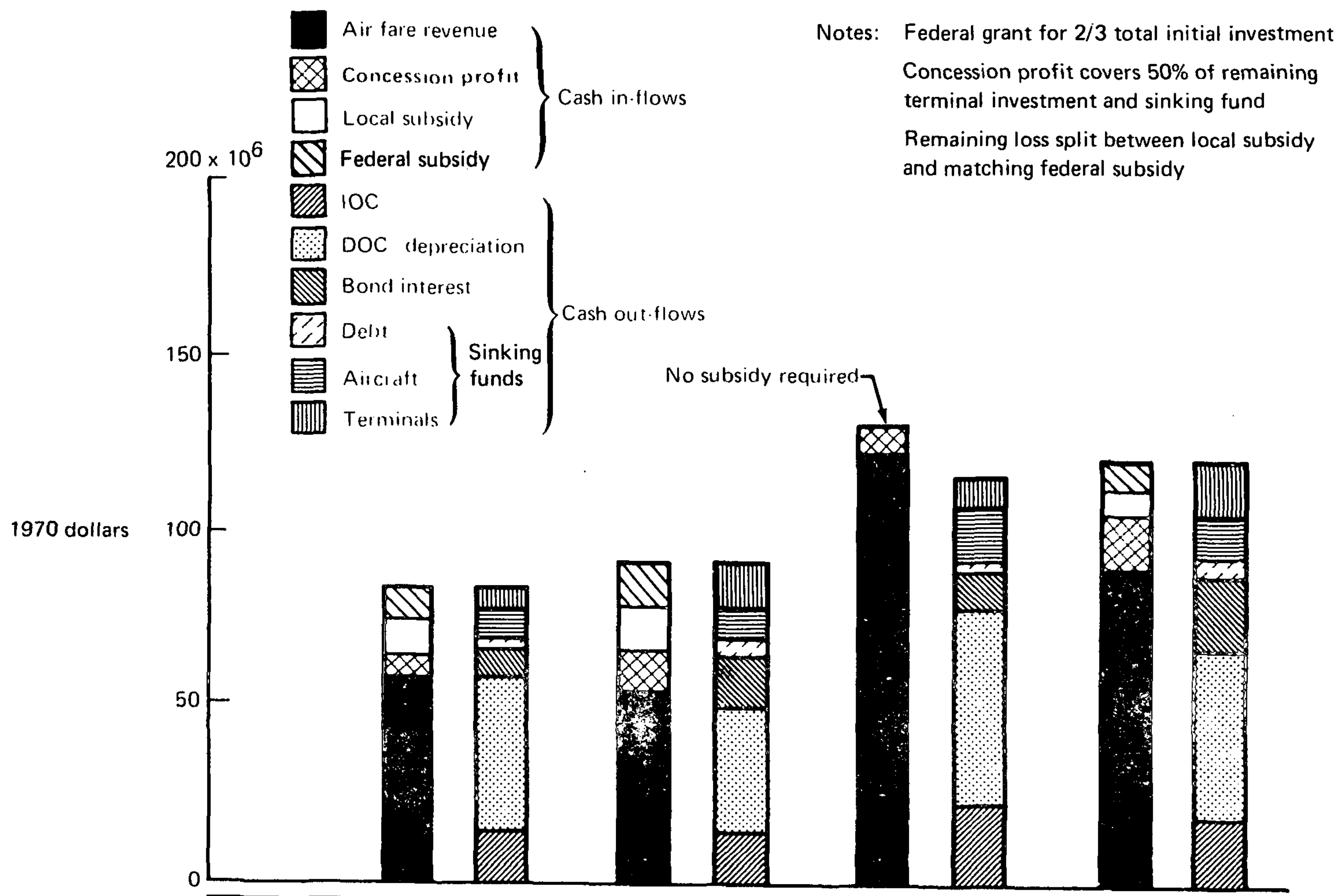
Vehicle	Helicopter	Augmentor wing STOL	Tilt-rotor VTOL	Augmentor wing STOL
Passengers	50	49	50	49
Technology	1975		1985	
Market	1980		1990	

FIGURE 5-19.—ANNUAL CASH FLOW C



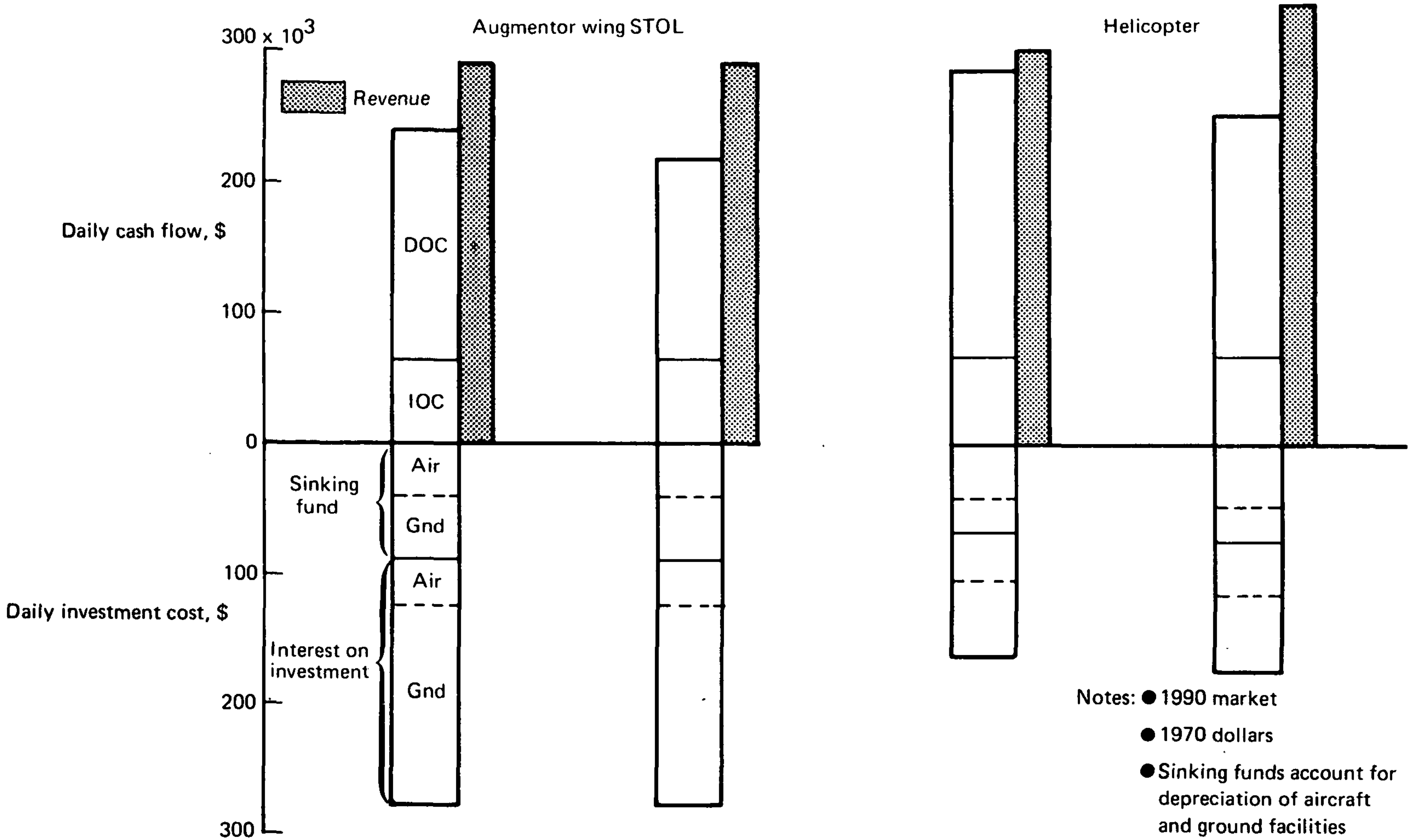
Vehicle	Helicopter	Augmentor wing STOL	Tilt-rotor VTOL	Augmentor wing STOL
Passengers	50	49	50	49
Technology	1975		1985	
Market	1980		1990	

FIGURE 5-20.—ANNUAL CASH FLOW D



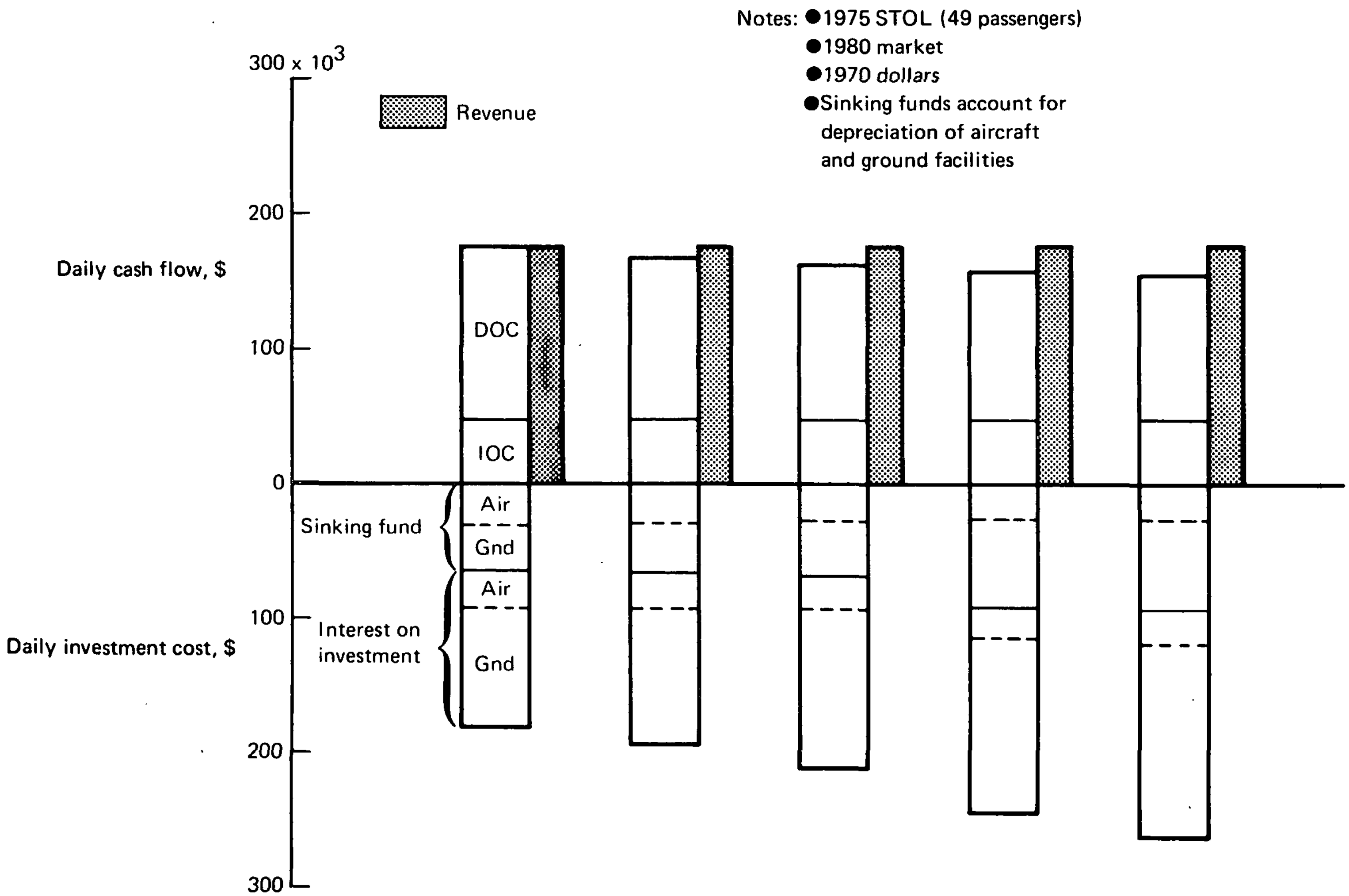
Vehicle	Helicopter	Augmentor wing STOL	Tilt-rotor VTOL	Augmentor wing STOL
Passengers	50	49	50	49
Technology	1975		1985	
Market	1980		1990	

FIGURE 5-21.—ANNUAL CASH FLOW E



Vehicle	Augmentor wing STOL		Helicopter	
Passengers	49		50	
Loss per passenger	$2.86	$2.57	$1.77	$0.95
Technology	1975	1985	1975	1985

FIGURE 5-22.—TECHNOLOGY SENSITIVITY



Field length, ft	1000	1500	2000	2500	3000
m	305	457	610	762	915

FIGURE 5-23.–FIELD LENGTH SENSITIVITY

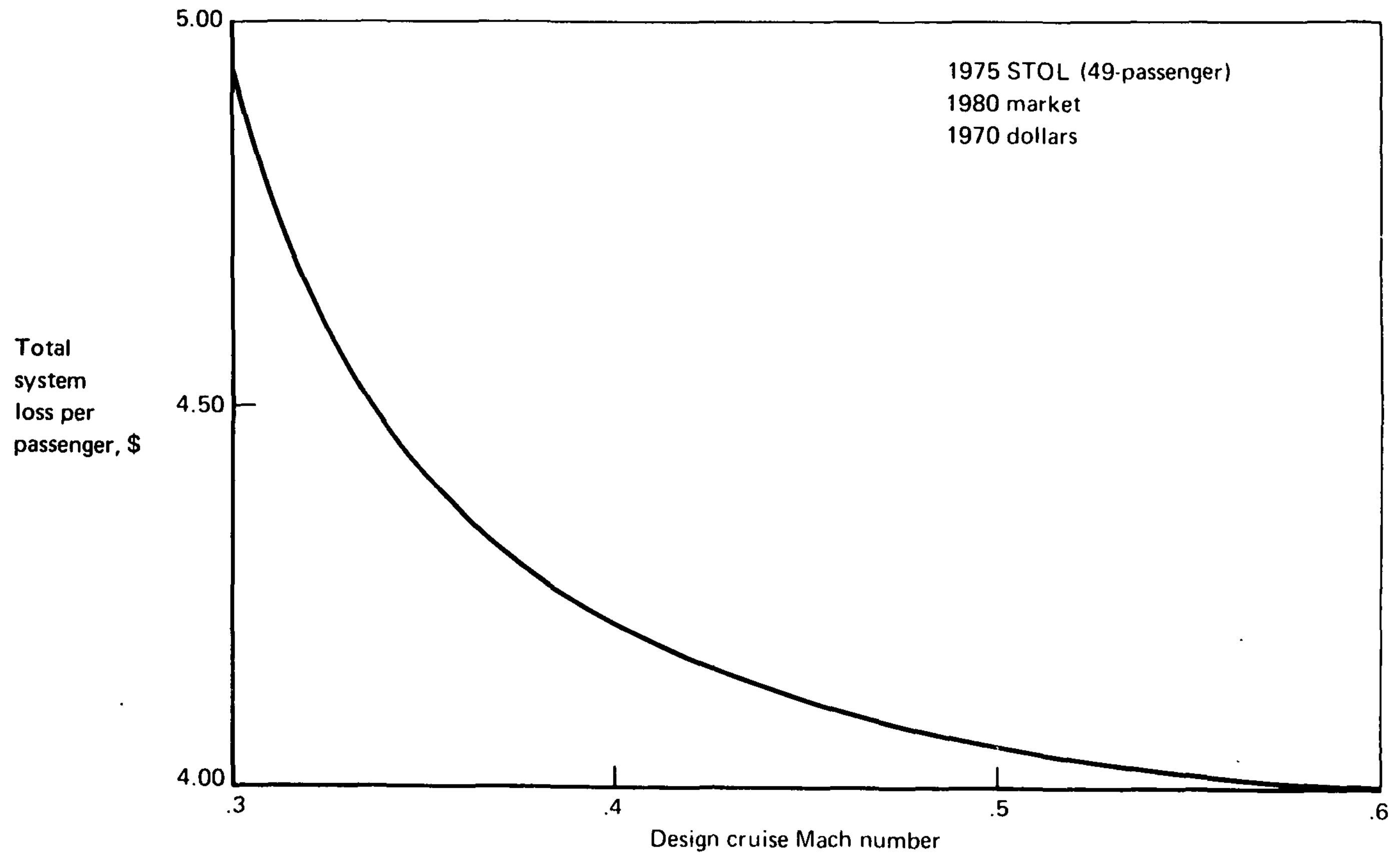


FIGURE 5-24.—DESIGN CRUISE MACH NUMBER SENSITIVITY

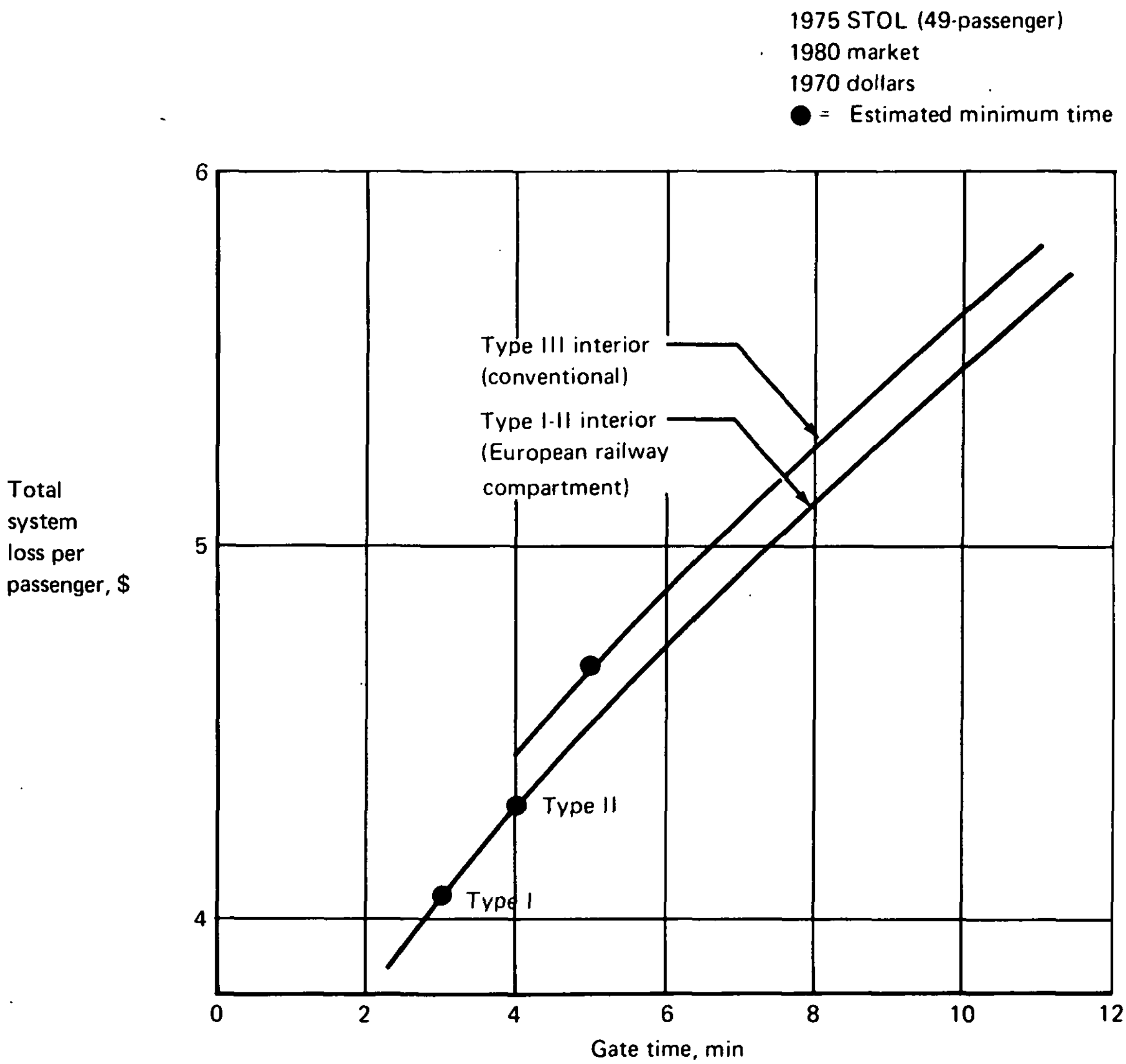
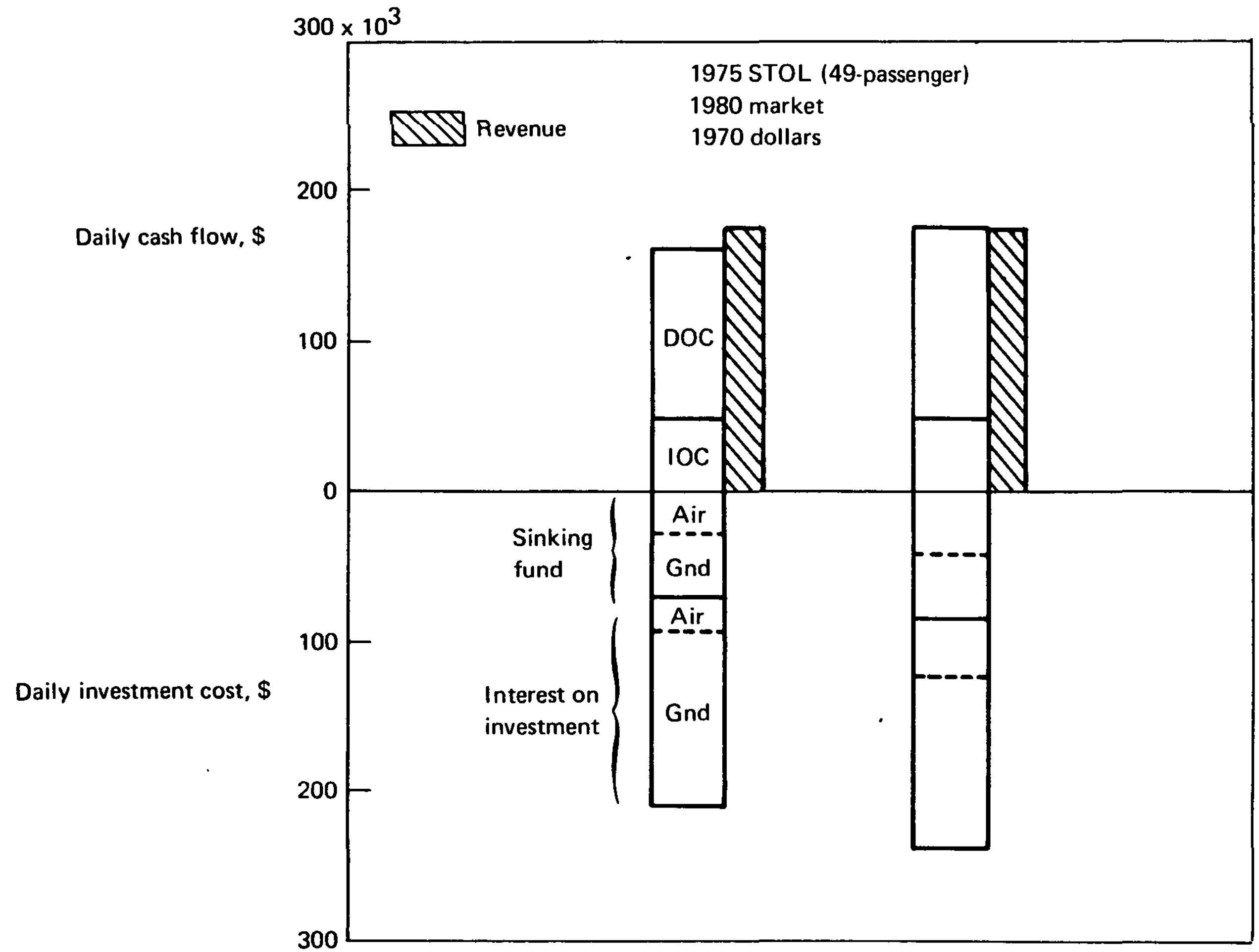


FIGURE 5-25.—GATE TIME SENSITIVITY



Production quantity	1500-2000	300-400
Loss per passenger	$4.05	$4.91

FIGURE 5-26.—PRODUCTION QUANTITY SENSITIVITY

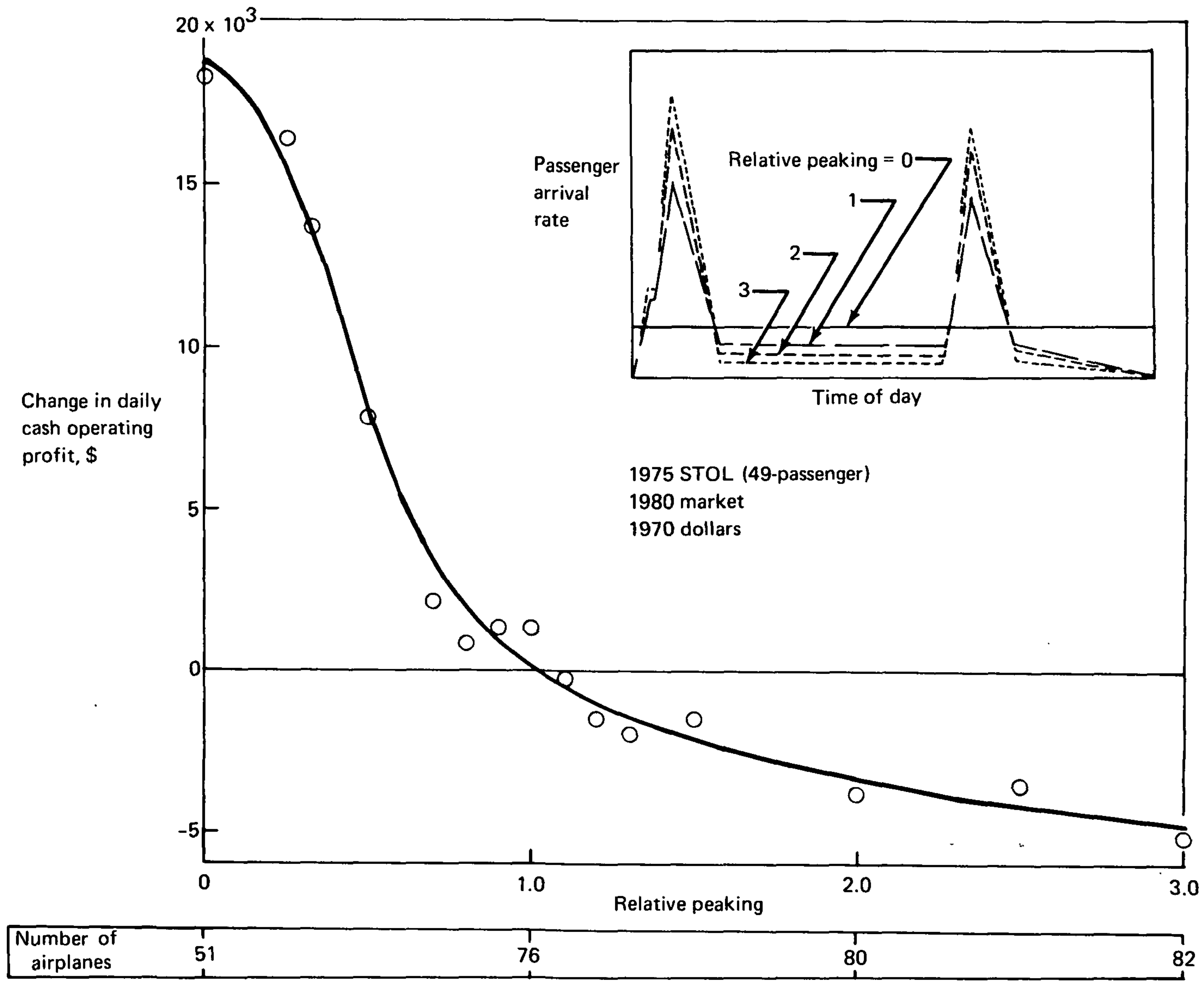
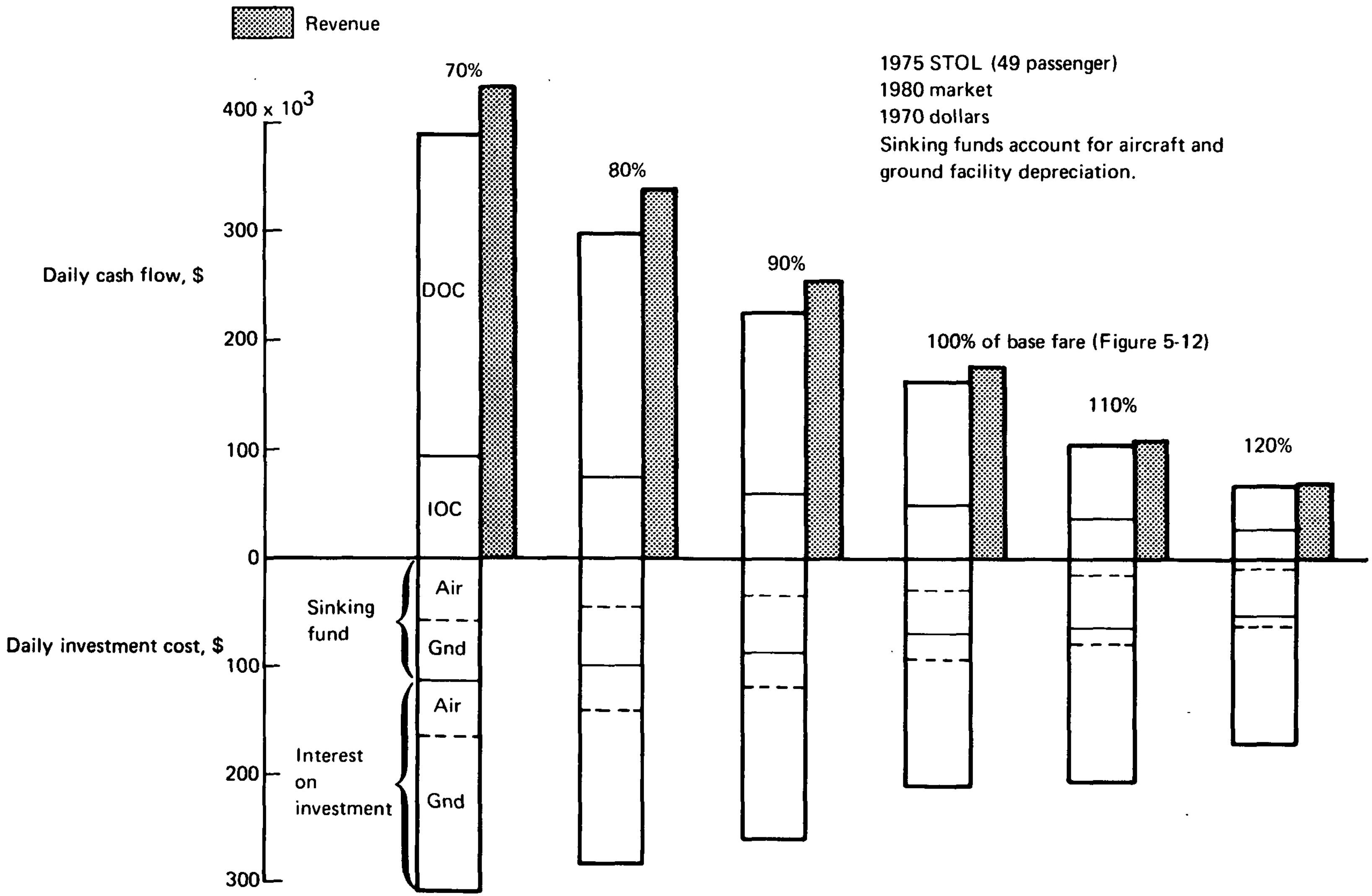
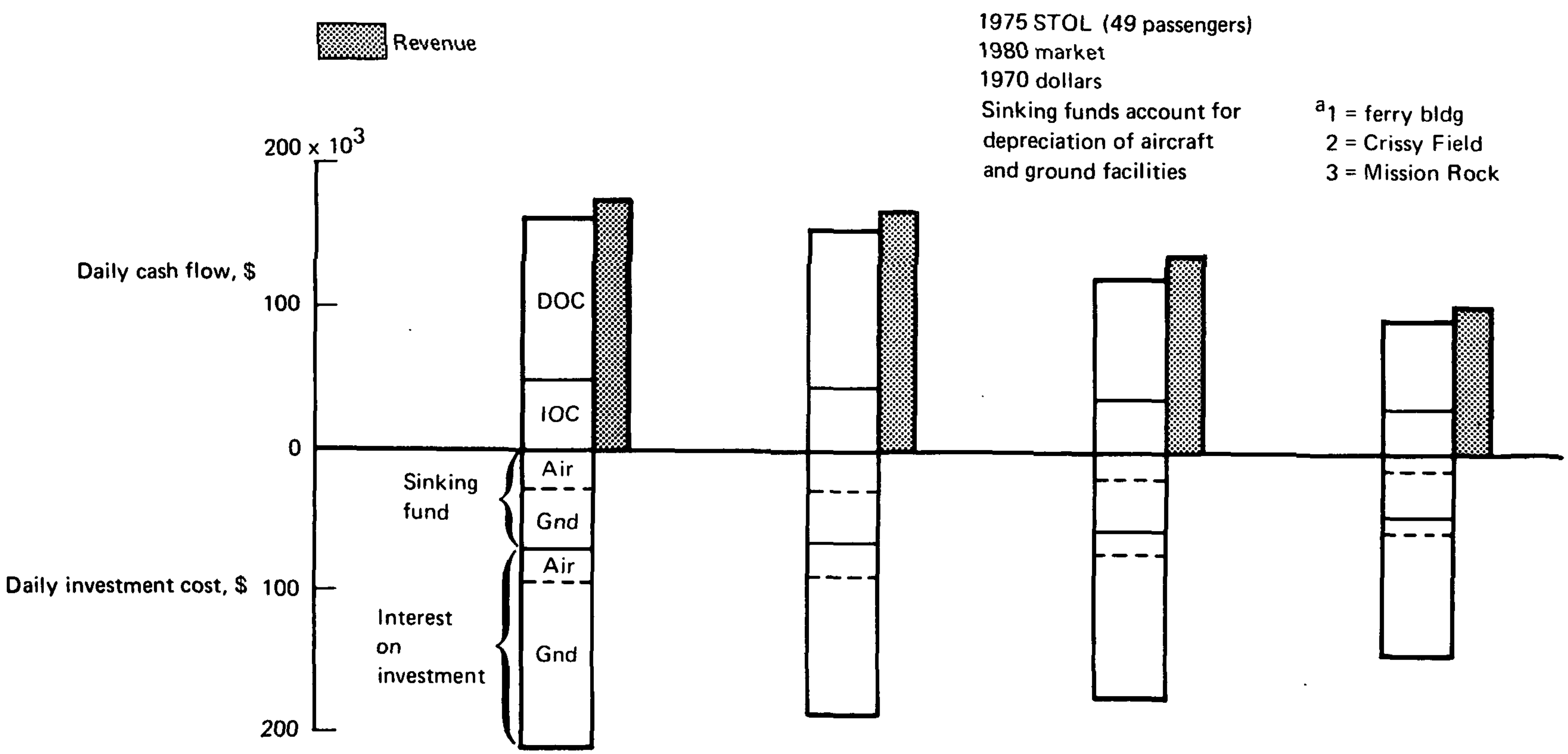


FIGURE 5-27.–PEAKING SENSITIVITY



Daily passengers	173 648	119 243	78 922	48 551	26 582	14 501
Average load factor	0.57	0.53	0.49	0.45	0.44	0.41
Loss per passenger	$1.53	$2.04	$2.92	$4.05	$7.66	$11.55

FIGURE 5-28.—FARE LEVEL SENSITIVITY



Ports eliminated[a]	None	1	1,3	1,2,3
Daily passengers	48 551	46 355	37 700	28 149
Loss per passenger	$4.05	$3.82	$4.19	$4.68

FIGURE 5-29.—SYSTEM SENSITIVITY TO ELIMINATION OF DOWNTOWN STOLPORTS

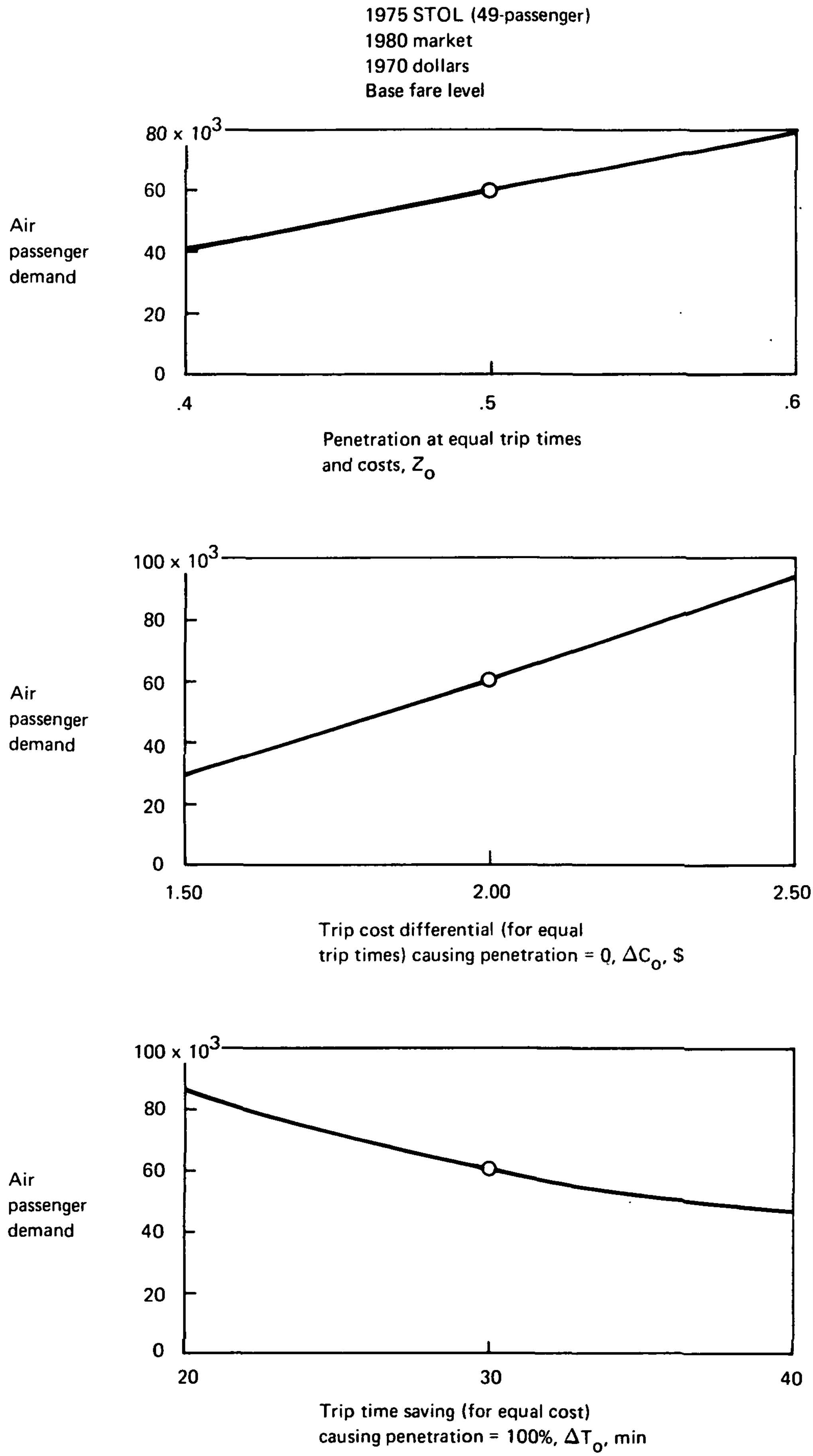
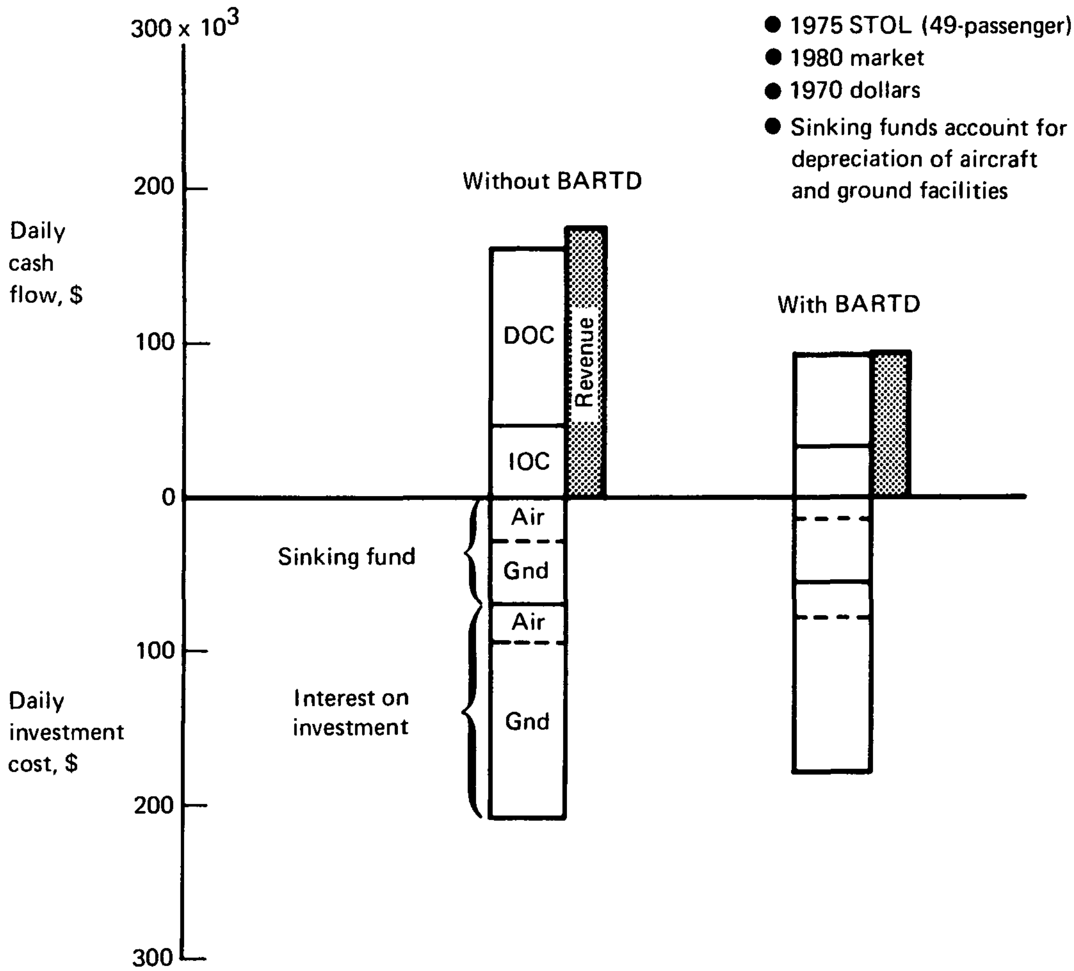


FIGURE 5-30.—MODAL-SPLIT INTERCEPT SENSITIVITIES



Loss per passenger	4.05	6.93

FIGURE 5-31.—EFFECT OF BARTD COMPETITION

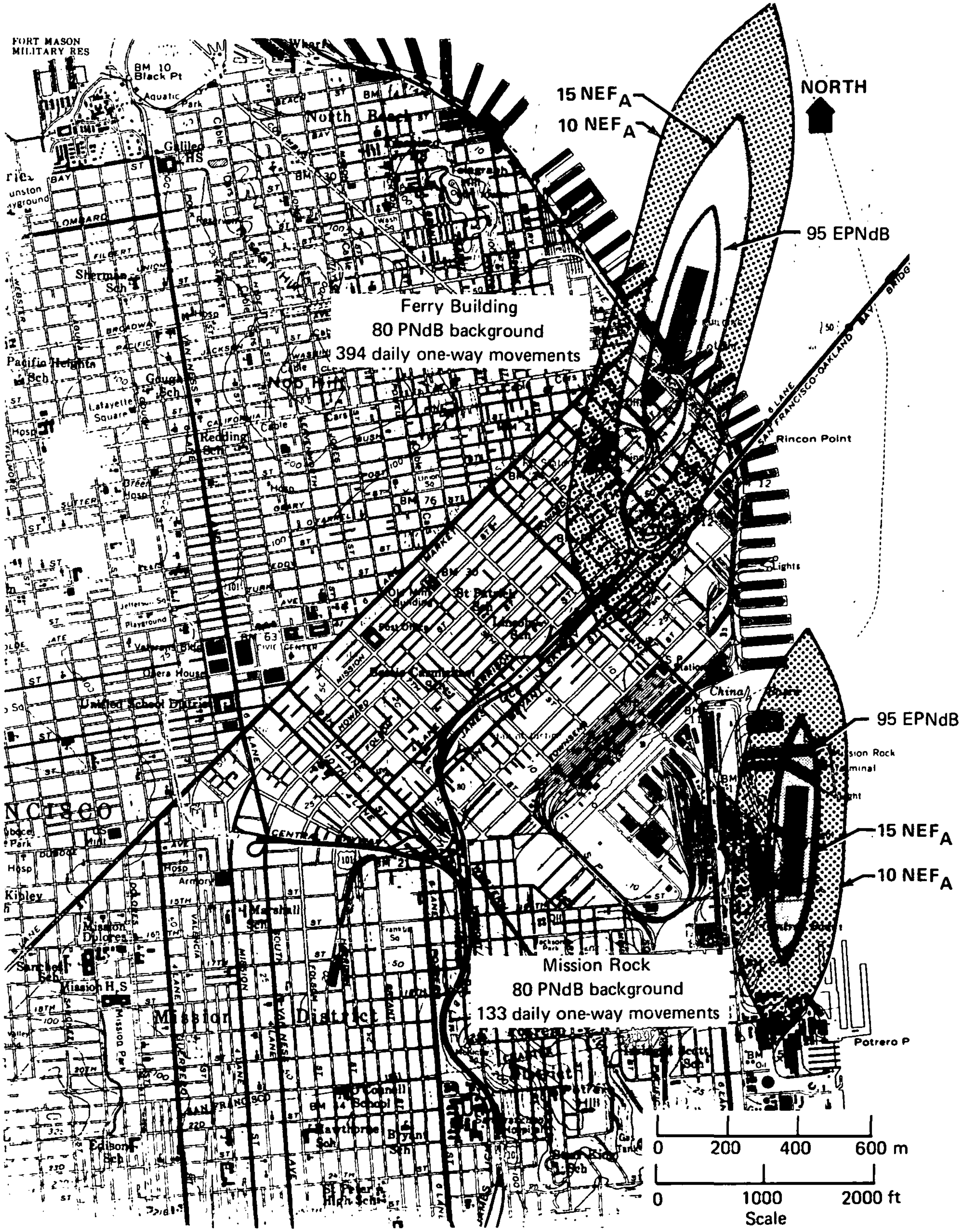


FIGURE 5-32.–COMMUNITY NOISE CONTOUR–STOL IN DOWNTOWN SAN FRANCISCO

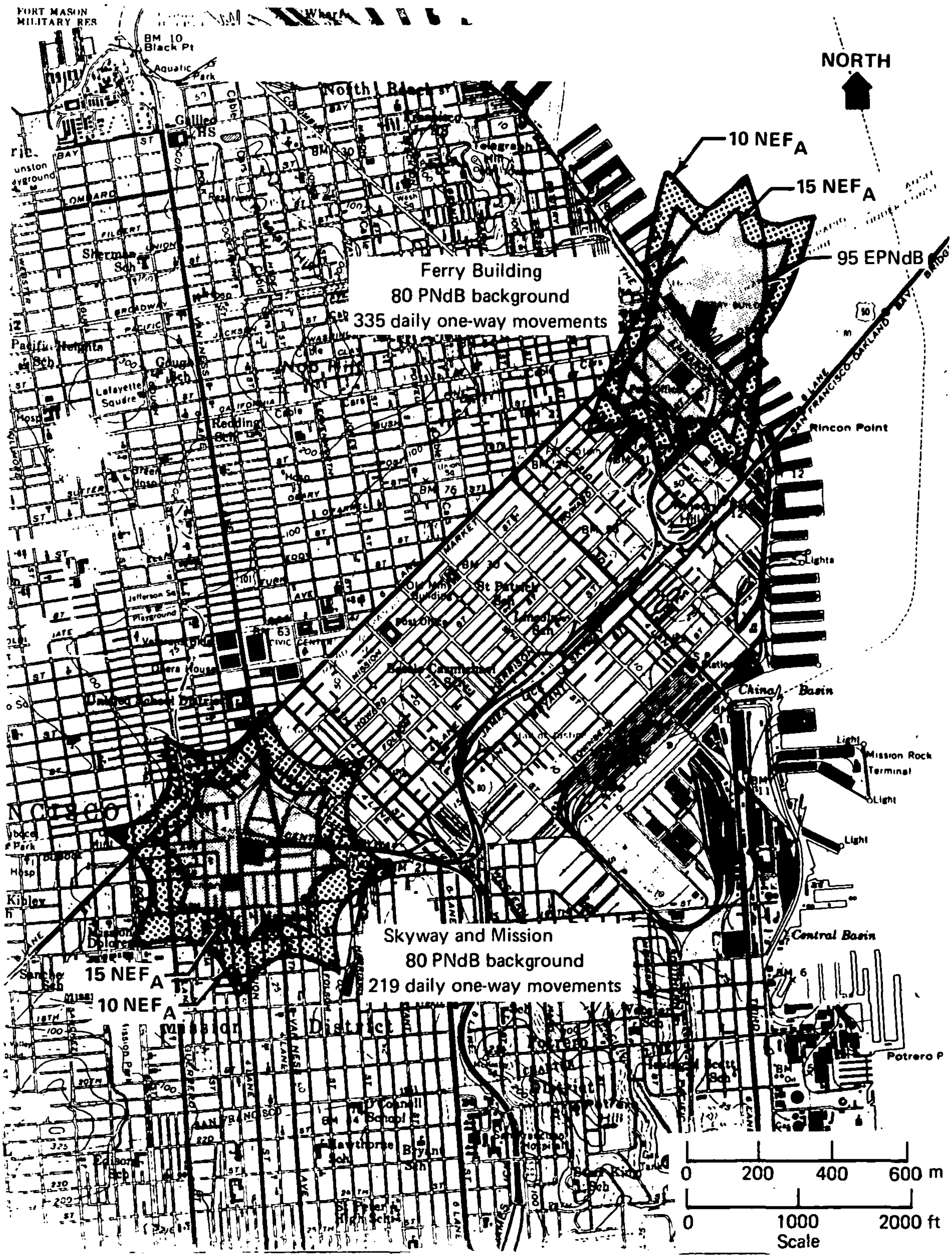


FIGURE 5-33.–COMMUNITY NOISE CONTOUR–HELICOPTER IN DOWNTOWN SAN FRANCISCO

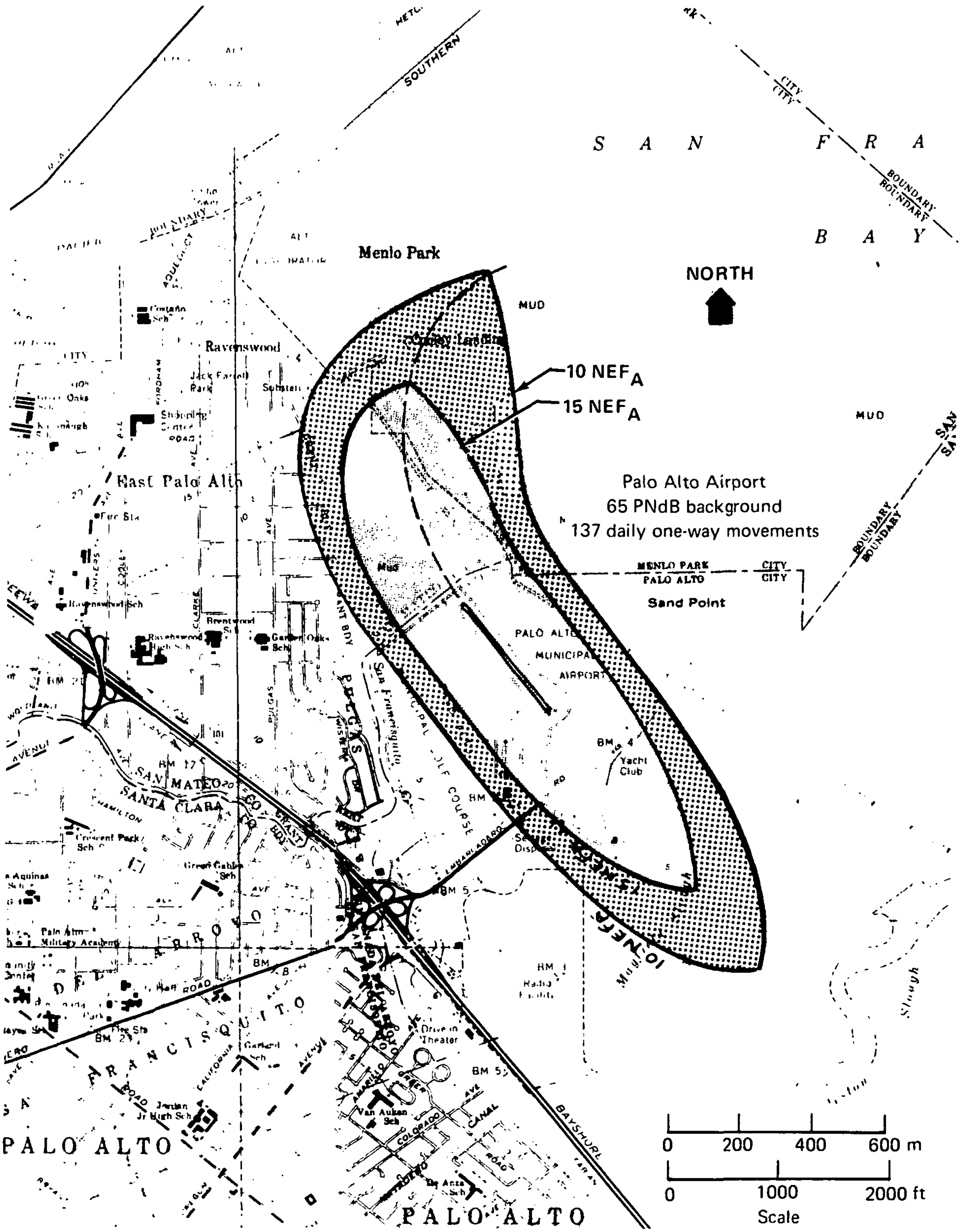


FIGURE 5-34.–COMMUNITY NOISE CONTOUR–STOL AT PALO ALTO AIRPORT

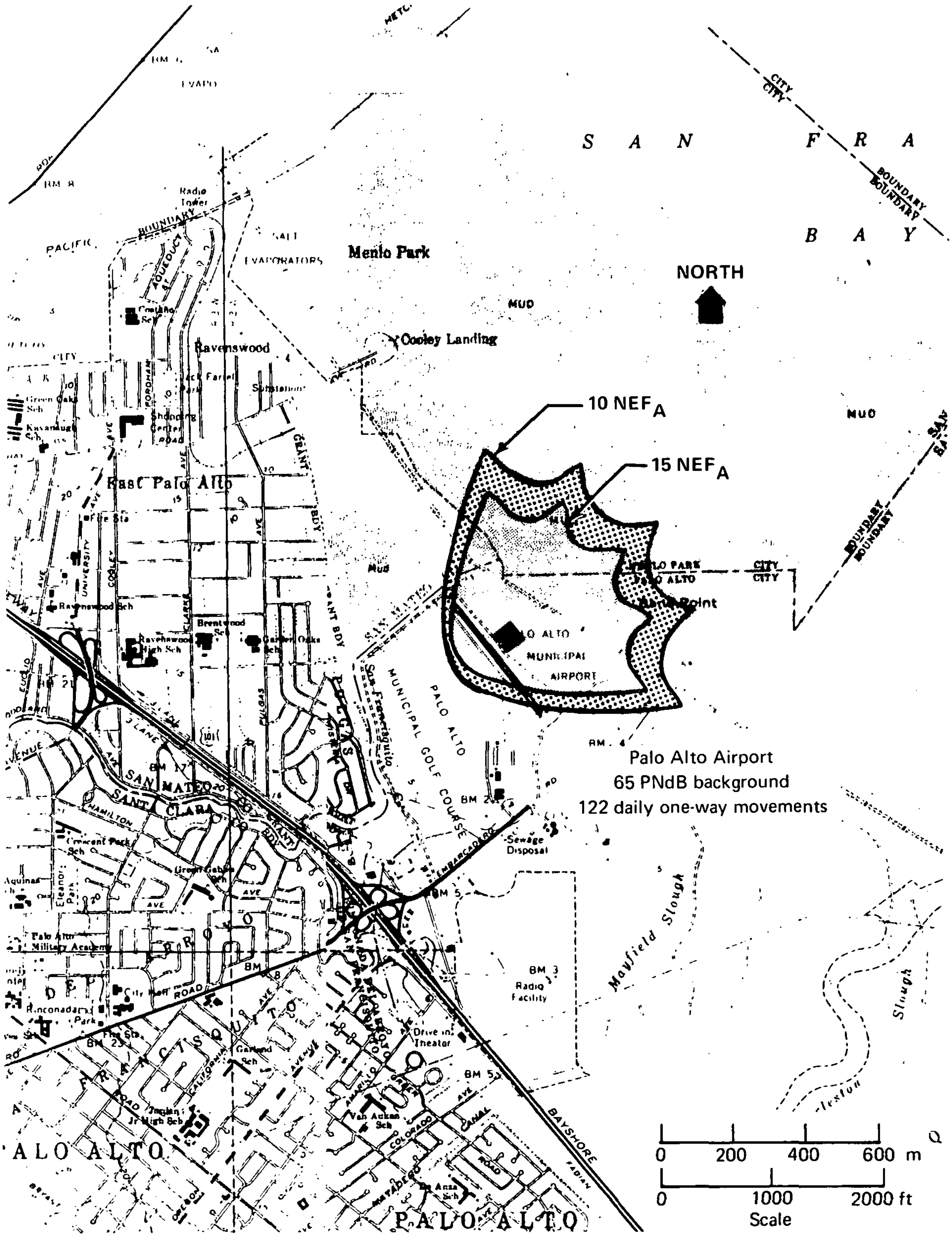


FIGURE 5-35.–COMMUNITY NOISE CONTOUR–HELICOPTER AT PALO ALTO AIRPORT

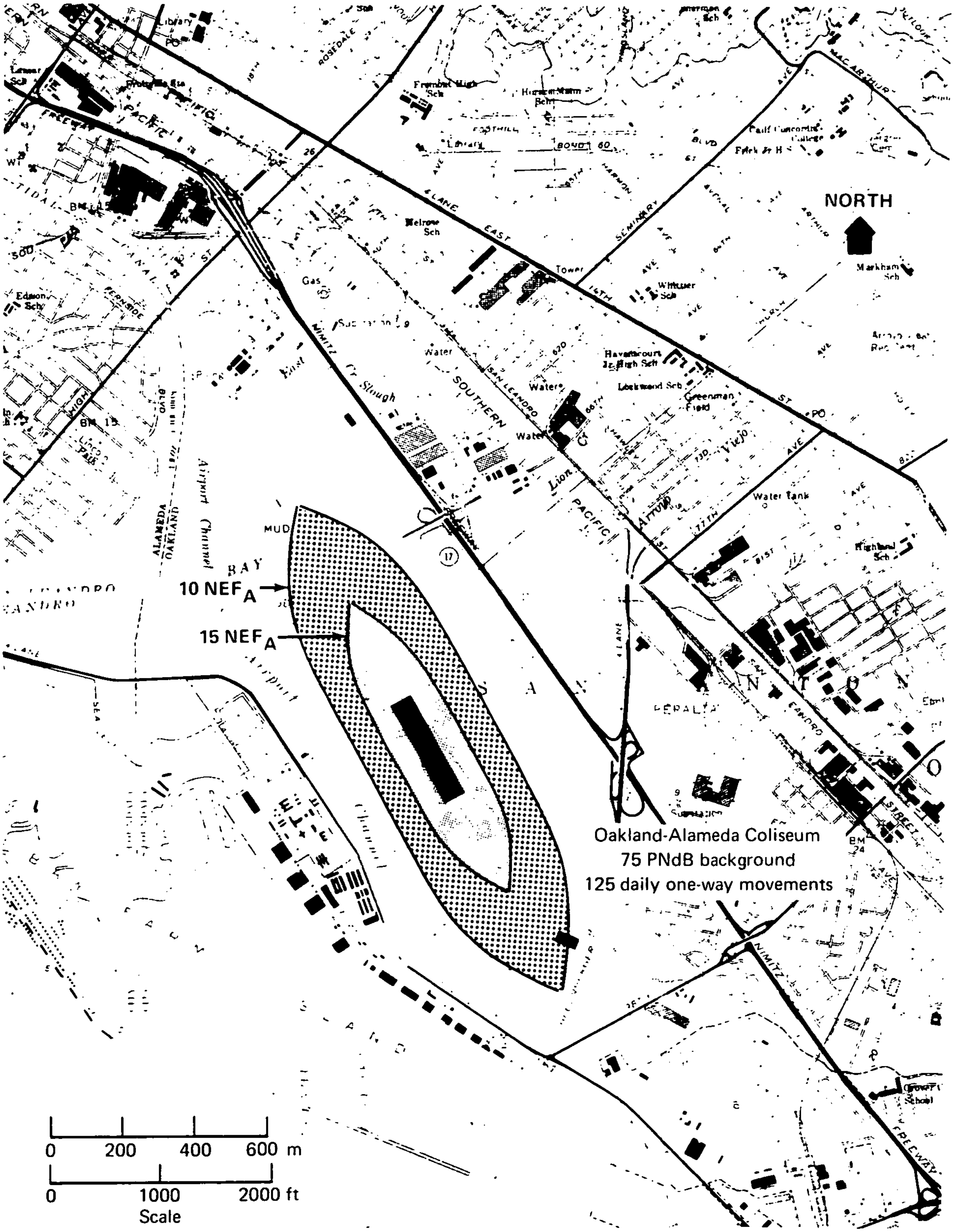


FIGURE 5-36.–COMMUNITY NOISE CONTOUR–STOL AT OAKLAND-ALAMEDA COLISEUM

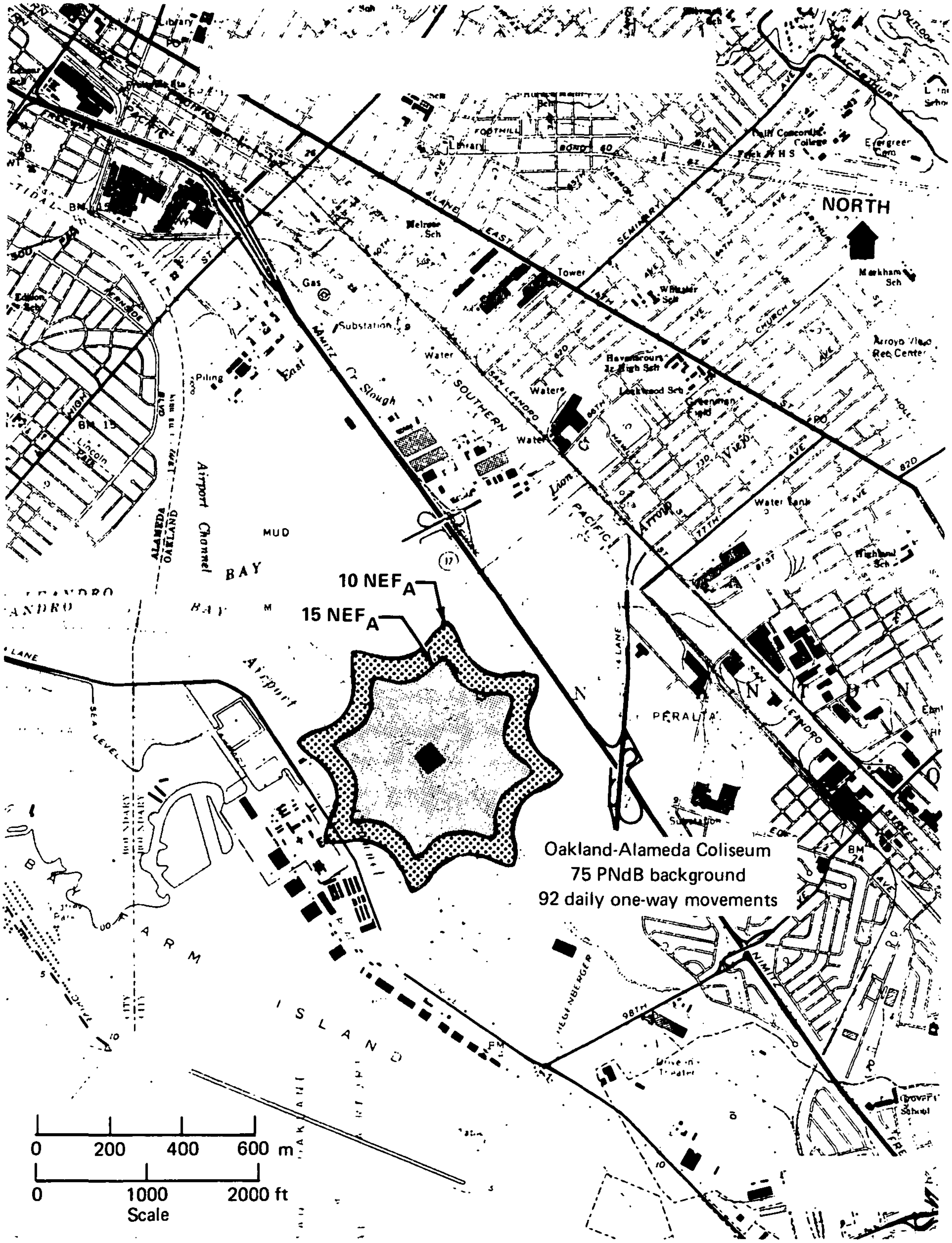


FIGURE 5-37.–COMMUNITY NOISE CONTOUR–HELICOPTER AT OAKLAND-ALAMEDA COLISEUM

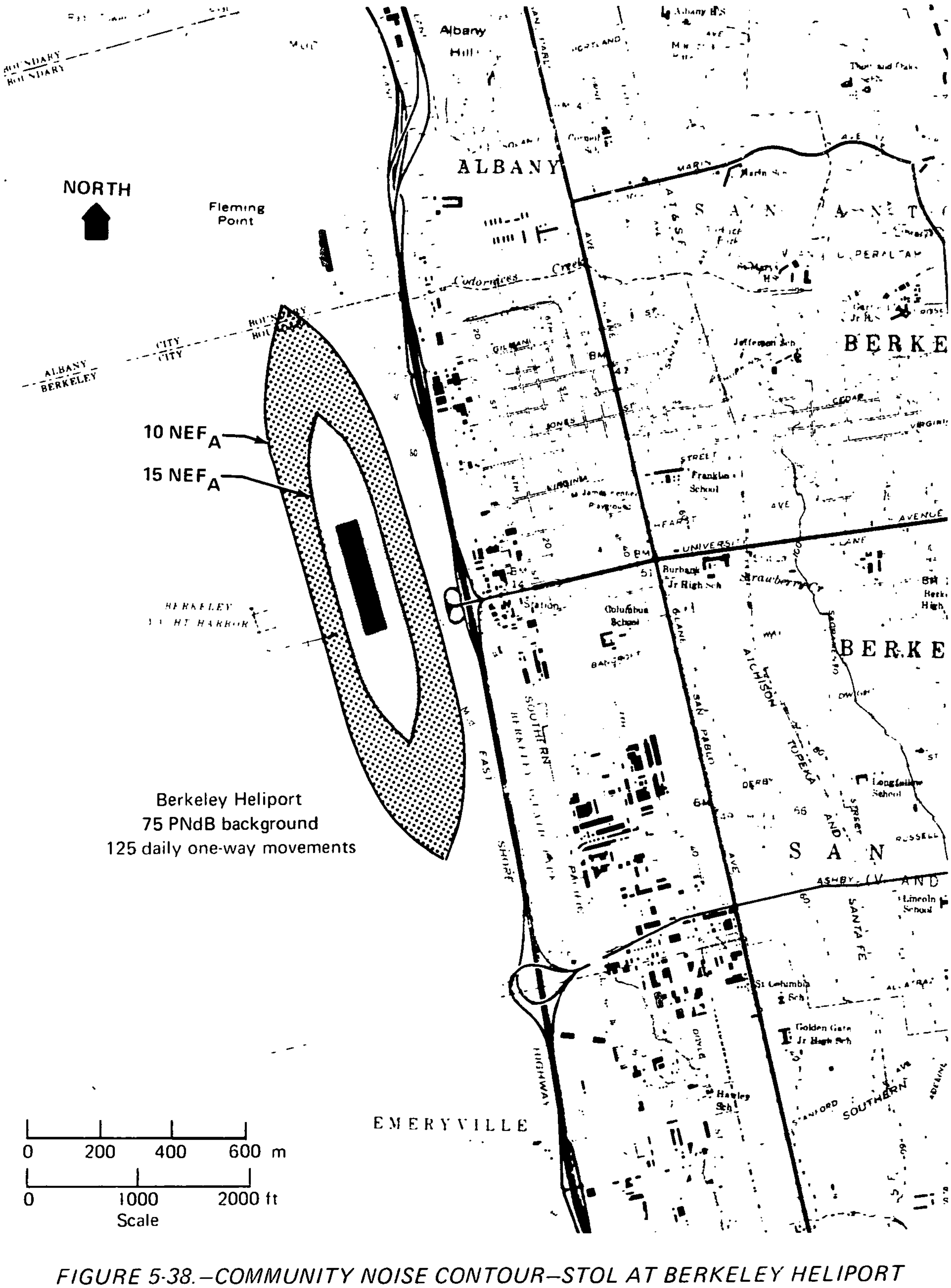


FIGURE 5-38.–COMMUNITY NOISE CONTOUR–STOL AT BERKELEY HELIPORT

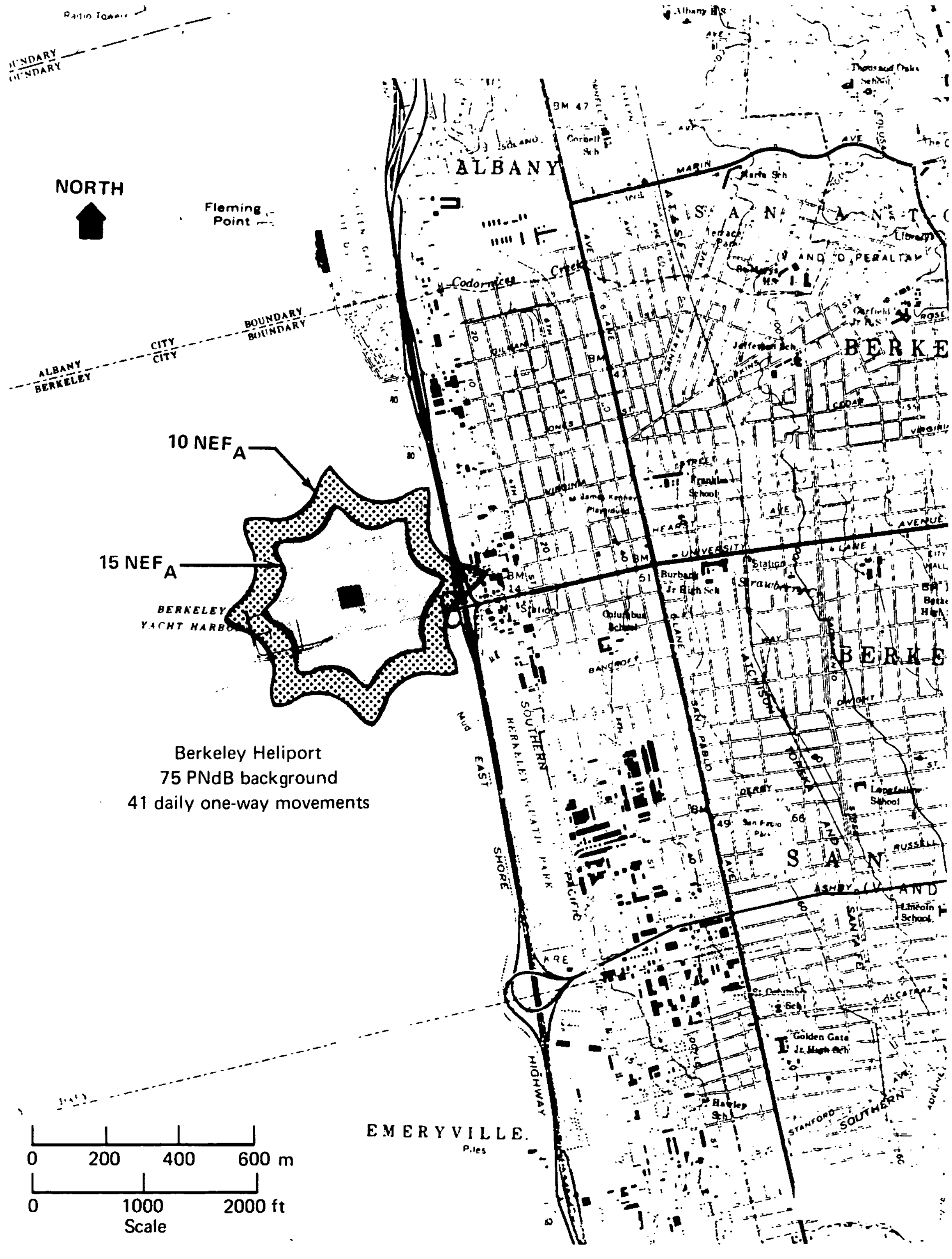


FIGURE 5-39.—COMMUNITY NOISE CONTOUR—HELICOPTER AT BERKELEY HELIPORT

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6.0 TECHNOLOGY AND CONFIGURATION ANALYSIS

6.1 ADVANCED TECHNOLOGY

6.1.1 Basic Airplane Sensitivities

The operational requirements of a very-short-range airplane are substantially different from those of the long-range airplanes in production today. In the design of a long-range airplane, the greatest emphasis is placed on minimizing the takeoff gross weight by maximizing the range factor and by careful structural design to eliminate excess weight. While these items are still important to the design of a very-short-range airplane, the sensitivity of the takeoff gross weight to the range factor and structural weight variation is very much reduced. Each of the principal technology areas will be investigated briefly to show how these sensitivities vary with design range.

6.1.1.1 Structural

The premise used in the structural sensitivity analysis is that excess structural weight has crept into the design forcing an overall increase in the size of the airplane, an increase in fuel consumption, but no increase in payload. An approximate method of treating this problem is to assume that the incremental increase in structural weight is equivalent to an increase in payload plus payload-related items. Then, by analyzing a number of existing commercial airplanes with a wide variation of design payload and range, a curve of $\partial GW / \partial \Delta W$ can be generated, where ΔW represents the excess structural weight. The data have been plotted against range with the range variation being indicated. The data appear to be relatively consistent up to a range of 3000 nmi (5550 km) but become scattered at the higher ranges due to the small quantity of data available, see figure 6-1. The point of particular interest is that the derivative $\partial GW / \partial \Delta W$ is a minimum in the range bracket of interest for the intraurban study and is approximately half the value found in the intercontinental-range airplane. Basically, this is the justification for the initial study assumption that structural simplicity was more important than design optimization to minimize weight.

6.1.1.2 Range Factor

The second term analyzed is the gross weight sensitivity to variation in range factor. The analytical expression for this sensitivity is derived from the Breguet range equation by differentiating gross weight with respect to range factor. The expression is

$$\frac{\partial W'_{GW}}{\partial R'} = \left(\frac{R}{W_{GW}}\right)\left(\frac{\partial W_{GW}}{\partial R}\right) = \frac{\left(1 - \frac{W_{MF}}{W_{GW}}\right)}{\left(\frac{W_{MF}}{W_{GW}} - \frac{\partial W_{MF}}{\partial W_{GW}}\right)} \frac{\text{Range}}{573\ R}$$

where:

W_{MF} = weight of mission fuel

W_{GW} = maximum gross weight

R = mission range factor

Current available data for a variety of commercial airplanes have been used to evaluate the expression. These data are presented in figure 6-2 together with a line indicating the approximate variation of least sensitivity with range. The main point to be noted from the figure is that the gross weight of the intraurban-class airplane is approximately an order of magnitude less sensitive to mission range factor than the intercontinental-class airplane.

The above brief analysis indicates that the gross weight of the intraurban-class airplane is basically insensitive to structural weight perturbations, aerodynamic cleanliness or optimized engine cycle. As will be pointed out in the study, the critical areas to airplane economics are a speedy turnaround at the airport and airplane reliability.

6.1.2 Aerodynamics

6.1.2.1 Augmentor Wing STOL 1975 Technology

The augmentor wing airplane integrates the propulsion system with the wing aerodynamic lift and control systems. In order to analyze the low-speed performance of this type of airplane, the drag polar must combine both the aerodynamic and propulsion characteristics. The low-speed polars have been constructed using a modified form of the jet flap theory, where the polar for the jet flap is given as:

$$C_T = C_{D_0} + \frac{KC_L^2}{\pi A\!\!R + 2C_\mu} - RC_\mu$$

where:

C_T = net force coefficient in the drag direction

C_{D_O} = drag coefficient at zero lift and thrust

C_μ = thrust coefficient based on the isentropic thrust of the jet flap nozzle

R and K = experimentally determined constants

To adapt this expression for the augmentor configuration, C_μ is multiplied by the thrust augmentation ratio while engine ram drag and residual thrust, which by-passes the augmentor, are added as C_T increments. An example of the low-speed drag polar is shown in figure 6-3 for an airplane with a wing loading of 55 psf (268 kg/sq in.), an initial thrust-to-weight (T/W) ratio of 0.28, and a thrust split between the augmentor primary nozzle and the engine primary nozzle of 0.236/0.044. For the engine cycle considered here, a T/W of 0.28 requires an air mass flow of 14.4 slg/sec (210 kg/sec). Air flow and residual thrust are assumed to be directly proportional to augmentor primary gross thrust for the range of T/W values used in the takeoff field length estimates.

Lines of constant T/W may be plotted on the low-speed polars to obtain C_T available for acceleration or climb. Takeoff field lengths based on these polars are presented in figure 6-4.

6.1.2.2 Augmentor STOL 1985 Technology

The 1985 augmentor configurations will employ advanced duct and nozzle designs to permit operation at reduced noise levels. The design changes to the augmentor system necessary to achieve the reduced noise levels are assumed to have no effect on the overall low-speed airplane performance.

A closer definition of the aerodynamic trades involved in advanced augmentor design will require flight and wind tunnel testing.

6.1.2.3 Wing-Tip-Mounted Engines

The augmentor propulsion system permits the use of wing-tip-mounted engines without introducing large yaw control requirements to counter moments caused by a failed engine.

For the case considered, the engine gross thrust is split approximately 85%/15% between the augmentor primary nozzle and the engine primary nozzle. The 85% of the engine gross thrust developed in the augmentor primary nozzle is uniformly distributed spanwise and introduces no yawing moments. Ram drag acting on the engine inlet and the engine primary gross thrust are compensating. As speed increases during the takeoff run, the magnitude of the ram drag increases until it equals the primary gross thrust. At this point, the yawing moment due to a tip-mounted engine is zero, see figure 6-5.

6.1.2.4 1975 Helicopter

The rotor characteristics are based on the Boeing-Vertol advanced-geometry rotors, which are applicable to the next generation of production helicopters and are being tested experimentally. These rotors have tapered thicknesses with low thickness-to-chord ratio (6%) tip sections and recently developed airfoil sections with improved L/D characteristics relative to present production rotors.

6.1.2.5 1985 Tilt Rotor and Helicopter

The rotor characteristics are based on the simplified elastomeric hub design, which will reduce the size of the hubs and hub fairings, and the use of fiber composite airframe construction. These improvements are assumed to reduce hub drag by 30% and basic skin friction drag by 10%.

6.1.3 Propulsion

6.1.3.1 Augmentor Wing Engine

The augmentor wing, as conceived by The Boeing Company, uses fan engines that direct all of the fan air into the wing where high suppression of the aft-fan noise is achieved through use of the ejector-suppressor characteristics of the augmentor. The primary jet noise is kept at a low level by extracting practically all the energy from core engine flow creating a low-velocity jet. Energy extraction from the core flow is accomplished by driving a high-pressure-ratio fan at a higher bypass ratio than performance considerations alone would dictate. This concept is illustrated by figure 6-6. A fuel flow and a weight penalty must be paid to achieve this end; however, the result is a propulsion concept with the potential for achieving a very low noise level.

Potential benefits in silencing the core jet noise are illustrated in figure 6-7.

To fully realize the noise potential of The Boeing Company augmentor wing cycle it must be coupled with a sonic inlet. One of the secondary advantages of this cycle is that the high-pressure-ratio fan is more easily matched to a sonic inlet than the low-pressure-ratio fans of high-bypass-ratio engines.

Some of the cycle and noise parameters of interest for the augmentor flap cycles chosen for this tudy are listed in table 6-1.

It is difficult to assess a meaningful installation penalty for the augmentor flap cycle since the propulsion system is totally integrated with the airframe. High pressure losses are caused by the need to duct fan air through the wings to the augmentor flap. These pressure losses combined with the pressure losses caused by the sonic inlet, result in approximately a 10% decrease in takeoff thrust. In considering this number, it must be realized that the engine cycle itself has already been compromised resulting in some additional performance penalties. A valid comparison of penalties and advantages for The Boeing Company augmentor flap cycle can only be made by comparison with other propulsion concepts over similar airplane missions.

6.1.3.2 Special Engines

It has been pointed out that the Intraurban Transport System economics are not highly sensitive to propulsion system and fuel weight. However, the system is sensitive to initial

and to maintenance cost of the engines. This suggests the possibility of having the engine manufacturer concentrate on producing cheap, rugged engines and letting performance be a secondary consideration. Low pressure ratio, low turbine inlet temperature engines operating at less than state of the art efficiency levels could be developed at low risk, reducing initial engine cost. Deliberately overdesigning components and accepting weight penalties will reduce maintenance costs.

Pratt & Whitney Aircraft have offered some comments regarding the above low-cost engine. On the basis of their preliminary analysis, they believe that:

- A 20-25% reduction in first cost might be achieved.
- The maintenance cost might be reduced by 20%-30%.

These reductions could be achieved by reducing the disc cost and increasing the disc cycle life at the expense of weight and sfc penalties. The weight penalty for increasing disc cycle life would require a detailed analysis of a specific design. Quantitatively, the engine weight increase should be less than 15% and the sfc penalty less than 10%.

6.1.3.3 1985 Propulsion Technology

Improvements in engine performance from 1970 to 1985 will be available from increased turbine inlet temperature, bypass ratio, overall compressor pressure ratio, reduction in weight, and better design integration.

At a given level of efficiency, increases in turbomachinery stage pressure ratios will occur. Since fewer stages will be required to produce a given overall pressure ratio, engine length will be reduced. Weight reduction will result from reduced engine length, development and use of new materials, and increased turbine inlet temperatures available. Projected improvements in engine length, weight, and turbine inlet temperature are shown in figures 6-8, 6-9, and 6-10, respectively.

The design compromises necessary to develop low-noise/low-smoke propulsion systems will offset the performance improvements possible by the traditional paths mentioned above. The special engine installation problems associated with STOL airplanes will increase the difficulty of achieving the full performance potential available.

6.1.3.4 Propulsion System Noise and Pollution

Noise is a paramount design consideration today, and it will continue to be so in the future. Propulsion system noise will be the most important design criteria for STOL aircraft. Performance degradation due to design compromises may be inevitable. To reduce fan noise, the engines of today have reduced fan-tip relative Mach number, increased spacing between the fan rotor and fan exit guide vanes, and use acoustic lining in the inlet and fan duct. As

aircraft noise regulations become increasingly stringent in the future, and to afford the desired "close in" STOL operation, use of sonic inlets, acoustic splitters, and nonoptimum engine cycles are some of the steps that will be taken—unless fundamental discoveries are made in understanding the fluid dynamics of noise generation and techniques for eliminating the sources of noise are developed.

The pollution level shown for the intraurban transport in figure 6-11 is based on data for engines of the JT9D-CF6 class and does not, therefore, reflect any technology improvements possible in the next 15 years. According to the average mission data, 75% of the total mission time is spent with the engines at idle. Exhaust emission data on the generation of high bypass engines now entering service indicate an idle emission index on the order of 10 times that at power settings typical of approach and above. Therefore, the level shown for the intraurban transport is relatively high compared to a longer range aircraft where a greater proportion of the mission time is spent at high power settings. Even at this, however, on an equivalent seat-mile basis, it emits about a third of the pollutants of an automobile meeting the proposed 1975 HEW Federal Standard and only a twenty-fifth (1/25) as much as the average light aircraft of today. It seems reasonable to assume that by 1985 the technology to produce combustors exhibiting a 75% reduction in idle emissions without serious performance or weight penalties should be well in hand. This would reduce the level shown by a factor of 3.

The data shown for light aircraft are taken directly from reference 6. Pollutants per 1000 seat-miles were computed by the methods of reference 7, where the reference mission was the same as that used in reference 6. Reference 6 contains a compilation of in-flight data taken on nine different aircraft in the four- to six-place single- and twin-engine categories. These aircraft are quoted as representing 68.5 percent of the light aircraft fleet according to figures compiled by the FAA for aircraft both registered and carrying a valid airworthiness certificate. No tests were run on one- and two-place aircraft due to insufficient space within the cabin to accommodate the test equipment.

The data quoted for light aircraft are based on measurements taken immediately upstream of the exhaust stack exit. All of the aircraft were also configured to obtain data several inches beyond the exit to determine the presence or absence of afterburn, which would tend to reduce the quantity of pollutants actually emitted. However, there was no statistical trend to indicate any such benefits.

At the present time, there are no restrictions on pollutants from light aircraft. It seems likely that by 1985 there will be.

Another problem that exists around airports today is the intrusion of airport odors into the surrounding community. Airport kerosene-type odors appear to originate from vaporized fuel displaced out of storage tank and airplane vents and unburned hydrocarbons being exhausted from the engines during ground operations. Perceived odors can be reduced by masking them with perfumes such as used in diesel buses, by eliminating the direct venting of fuel tanks during fuel movements, and by engine designs that reduce exhaust emissions of hydrocarbons. Another approach would be to use an odor-free fuel whenever necessary.

For the intraurban system, refueling would not be done at each terminal. The few elevated terminals, for example, would not need to be complicated with rooftop refueling. In addition, a closed-venting system would be used, (primarily as a safety factor to allow refueling with the engines running).

The short ground time planned for the intraurban system will help keep the exhaust emissions (and odors) low. The remaining exhaust emissions add increased emphasis to the need for engine combustors that produce lower idle emissions. With proper attention paid to airport odors, intraurban terminals should be considerably less obtrusive.

6.1.3.5 VTOL Propulsion

For the 1975 time period, the T64/S5C-1 engine was used as the basis for performance calculations.

The engine is of the axial flow turboshaft type, with a two-stage, free-power turbine. The compressor is a 14-stage, axial compressor. The two-stage gas-generator turbine uses blade cooling to permit operation at high turbine inlet temperatures. The performance is generally commensurate with the engine development in the 1975 period.

For the 1985 time period, a general advanced performance was predicted, based on the probable development of a turboshaft engine of the GE1/S1A type. The engine is an axial flow, two-stage, free-power turbine type: a 14-stage compression similar to that of the T64 with the addition of variable inlet guide vanes, additional stator modulation, and extensive use of advanced materials. Cooling of the gas-generator two-stage turbine is assumed as well as use of high-temperature materials whose development would coincide with the time period under consideration.

Table 6-2 is a table of general engine parameters assumed.

6.1.4 Noise Technology

Technology development work is proceeding in the areas of turbomachinery noise relocation, sound attenuating duct lining development and engine cycle analysis. In all three of these areas, improved materials can have considerable impact on designing for airplane noise reduction. As is well known, there is often a considerable delay between the formulation of engineering concepts and the technology to put them into practice. This is particularly true of duct lining development where concepts of 10 years ago have but recently been developed to give effective performance in an engine. This has been largely a development of suitable materials and processes.

6.1.5 Structures and Weight Analysis

This section summarizes potential structural materials, together with related weight reductions, expected on both 1975 and 1985 aircraft. Of the materials reviewed (see refs. 8 through 18), increasing use of titanium alloys is foreseen in aircraft of both time periods; the high-modulus advanced composites currently under intense study throughout the industry will provide a high percentage of the structural material for the 1985 aircraft.

Several advanced composites have been reviewed with the conclusion that graphite/epoxy and, to a lesser degree, boron/epoxy offer the greatest potential where strength or stiffness are required at minimum weight and environmental temperature problems are not a consideration.

V/STOL aircraft operating in the very-short-range flight regime under study will accumulate 180,000 landings and 36,000 flt-hr in a 20-year life. To achieve a high probability of crack-free life over this period, the airplane should be designed for 300,000 landings and 60,000 flt-hr. Fatigue and crack propagation characteristics, especially of the landing gear and associated structure, will obviously be a critical design factor.

The weight of advanced composite structure has been derived by applying weight reduction factors to current established weight estimation methods for aluminum alloy structure. A review of these reduction factors is presented.

Consideration has also been given to producibility and projected cost of the newer materials.

6.1.5.1 Structural Materials

A materials technology review indicates that many alloys and composite materials are now available or will be in the foreseeable future. Many of these are mentioned briefly, but only those materials that are expected to reach a timely stage of development, giving the degree of confidence required for commercial aircraft application, are seriously considered.

Aluminum.—Currently, the most widely used structural material is aluminum. Many alloy variations are available, although the aluminum-copper and aluminum-zinc systems typified by 2024, 7075, and 7079 are used almost exclusively in airframe construction today.

Steel.—The steel alloys 4130 and 4340 are in most common use today and are widely employed in such structural components as landing gear and flap tracks. Stainless steels, such as AM350CRT and the 18Cr-8Ni series, are used for functional components such as hydraulic lines. Trade studies, however, show that the use of steels will be reduced in future years and be replaced by titanium alloys showing meaningful weight reductions.

Titanium.—One of the more recent advances in materials technology is the practical application of titanium alloys to aircraft production. Due to its retention of material properties under elevated-temperature applications, titanium was first used in jet engine applications, and a high percentage of the titanium produced today is employed in this field.

Titanium development has progressed rapidly with the configuration and design of supersonic transports. A high percentage of these aircraft structures will be produced from the many titanium alloys now available and an increasing amount of titanium will also be used on subsonic aircraft.

Despite its high cost and fabrication problems, the high-strength, high-temperature capabilities and low density of titanium make it competitive with steel and aluminum alloys.

Titanium, in most of its alloy forms, is readily weldable, with weld metal giving strengths equal to parent metal, provided every precaution is taken to exclude the atmospheric gases oxygen, nitrogen, and hydrogen during the welding process. Welding obviates the need for bulky mechanically fastened joints giving a further weight reduction.

Of the available alloys, Ti-6Al-4V is in widest structural use while Ti-6Al-6V-2Sn and Ti-8Al-1M-1V are also used in certain applications. Hot-forming, consequent cleaning, and, usually, heat treatment are required with these alloys.

Another alloy, Ti-11.5Mo-6Zr-4.5Sn is being developed and has the advantage of cold workability. This alloy, known as Beta III, is attractive for riveting applications since it does not require the hot heading operations associated with other titanium alloys.

Beryllium.—Use of beryllium is limited mainly because of its high material and fabrication costs. It is included in this survey as a comparison because of its high modulus and low density. Current applications are limited, but its future potential, compared with aluminum alloys, is good.

S-glass/epoxy matrix.—High strength, low modulus of elasticity, and low density are characteristics of S-glass/epoxy matrix material that will be considered for secondary structure applications on these configurations.

Advanced filamentary composite materials.—A review of existing literature dealing with reinforced composites was made. Of the many possible and projected variations, it was considered that the boron and graphite filaments in epoxy or metal matrices were the most likely combinations for inclusion in this study. Other combinations were not expected to reach the required developmental stage by 1985.

Considering the importance of minimum weight to V/STOL configurations, the maximum use must be made of the available high-strength, high-modulus, low-density composites. Manufacturers have made heavy financial commitments in both research and production areas showing their confidence in the future of these materials.

Boron filament/epoxy matrix.—Several Boeing organizations and a number of other aerospace companies have conducted many design and laboratory studies with boron/epoxy composites over the past 5 years. These include test flying of a number of structures many of which have given a high degree of confidence in the design and fabrication methods used.

A filament content of 50% is considered optimum by most investigators, and the composite properties shown in figures 6-12 through 6-15 are based on this volumetric fraction.

A number of improvements are considered likely in both the filament and matrix by 1985. Cracking of the tungsten core filament is a problem that may be solved by substituting another core material. Improved matrix materials are being developed that will improve filament efficiency in a given composite.

Graphite filament/epoxy matrix.—This composite is expected to fill the bulk of aerospace demands in the foreseeable future and a high percentage of this material is envisaged on the 1985 configuration for the following reasons:

- Higher specific strength and specific modulus than boron/epoxy
- Better draping or forming qualities in the layup stage than boron/epoxy due to its smaller filament diameter
- Drilling or machining of the cured composite possible
- Low-cost potential of both filament and finished structure
- More interest shown in development of this composite than boron/epoxy

Composite properties shown in figures 6-12 through 6-15 are based on a filament content of 60%, which is considered optimum in current studies.

Metal matrix composites.—This type of composite is now available and allows fabrication of structure by means of brazing or diffusion bonding. The metal matrix also has a higher load-carrying capability than epoxy matrices, a fact that affects filament orientation in many cases.

Metal matrices result in heavier composites than the epoxy matrix composites. They are, however, more suitable for end attachments and lend themselves to more conventional joining and fabrication methods.

Many different metal composites are possible, the most likely ones being:

- Boron filament/aluminum matrix
- Boron filament/magnesium matrix
- Graphite filament/aluminum matrix
- Graphite filament/titanium matrix
- Graphite filament/magnesium matrix

Relatively few studies have been completed to date on metal matrix composites, and their use is not envisaged on these configurations.

6.1.5.2 Design Criteria

All indications are that the 1975 airplanes will be of conventional aluminum alloy skin and stringer design, and weight estimates have been derived on this assumption. The 1985 configurations will use a percentage of graphite/epoxy composite and the corresponding weight reductions have been calculated by applying weight reduction factors to the aluminum alloy designs.

Graphite is produced in filamentary form, and direction of principal stresses in a structure determines the orientation and quantity of filament layup in a given matrix. With anisotropic materials such as this, stiffness and strength can be tailored to suit a given application. Figures 6-16 and 6-17 show anisotropic curves for some structural materials. These include potential 1985 properties for boron/epoxy and graphite/epoxy composites based on 90° laminate orientation.

Figure 6-18 shows the stress-strain relationship of several structural materials. The significant point's being the strain compatibility of aluminum, steel, titanium, boron/epoxy, and graphite/epoxy.

Provided single filament and matrix properties are known, most other composite properties can be predicted by the rule of mixtures. Such predicted properties, however, are generally higher than those obtained experimentally, and more research into composite microstructure and interfaces is required to give a better understanding of these problems. Figure 6-19 shows curves of E, G, and μ versus θ. The weight-reduction factors presented are influenced by strength-to-density and stiffness-to-density relationships, but consideration has also been given to other requirements that influence the percentage of aluminum alloy that can be replaced by advanced composites, e.g.:

- Filament orientation is a major factor in determining stiffness and strength of the cured composite with respect to a given axis.
- External composite surfaces require protection against rain erosion, stone and hail damage, and lightning strike in the form of an aluminum foil surface cover sheet.
- Minimum-gage aluminum alloy is still cost effective in some lightly loaded areas such as the fin tip.
- Joint design carries a weight penalty where metal edge attachments and mechanical fasteners are used. Improved bonding techniques and use of molded composites will eventually improve this position.
- Cutouts, such as fuel access doors, passenger doors, and windows, incur a weight penalty because the filament continuity is broken and alternate load paths, in the form of heavy edge members, must be provided.
- Cabin and freight floors are prone to damage and here only floor beams are assumed to use graphite/epoxy composite.

Figure 6-20 shows the probable use of graphite/epoxy through the 1970-1985 time period.

Projected graphite/epoxy composite properties for 1985 weight calculations are listed in table 6-3.

Using the preceding material properties and the assumptions and requirements stated earlier, the structural weight reduction for the 1985 aircraft are predicted as follows:

Wing	30%
Horizontal stabilizer	35%
Vertical stabilizer	35%
Body	25%
Main landing gear	0
Nose landing gear	0
Nacelle and strut	15%

These figures indicate that a weight reduction of 25% is possible in an airframe structure where graphite/epoxy composites are used to their full advantage.

6.1.5.3 Material and Manufacturing Costs

Current manufacturing methods consist of hand layup of small items and machine layup of larger structural items such as wing skins. Development of these methods promises cheaper manufacture, no material wastage, and less material requirements than equivalent aluminum alloy structure.

The 1970 price of graphite/epoxy composite is around \$250 to \$300/lb (\$550 to \$660/kg); predictions show that this price will fall drastically as demand increases.

Figure 6-21 shows projected fabrication costs of various structural materials in terms of dollars per pound of finished structure through the 1970-1985 time period. This shows graphite/epoxy structure to be cost competitive for the 1985 aircraft.

6.1.5.4 Weight Prediction Techniques and Future Improvements

Boeing empirical weight methods for preliminary design were used to estimate configuration weights for this study. These methods are based on statistical data representing operating commercial aircraft and are adjusted as necessary to reflect intraurban V/STOL design concepts.

The future improvements for structure, propulsion, and fixed equipment have all been measured from a 1970 level of technology. The following discussion defines structure, system, and equipment concepts represented by configuration weights for 1975 or 1985 operational aircraft.

Airframe structure.—The 1975 models use present-day construction materials and fabricating techniques. For the 1985 time period, graphite/epoxy composites have been assumed to replace much of the present-day airframe structure. Estimated percent reductions in airframe weights are noted in section 6.1.5.2.

Propulsion.—The propulsion systems on the 1975 V/STOL configurations contain paper engines scaled from a base-point model. The engine scaling parameters were supplied by the Boeing Propulsion Group.

The following list shows the percentage weight reduction in the propulsion system for the 1985 time period, measured from 1975 operational engines.

Engine	20%
Engine accessories Engine controls Starting system Fuel system Thrust reverser	At this time, no reduction factor could be applied to these items.

Fixed equipment.–The fixed equipment weight for the 1975 configurations reflect present-day systems, based on operating commercial aircraft.

The trends in the future will be toward more instrumentation and system redundancy especially for V/STOL aircraft. This equipment will increase the reliability and ensure fail-safe operation. Surface controls and hydraulic, pneumatic, electrical, and electronic systems will probably show an increase in requirements and capabilities. The above improvements would show a weight increase in the fixed equipment. However, these weight penalties will be offset by the development of solid-state systems for the instruments, electrical, and electronic groups. Miniaturization of components and the combining of various electrical functions will also tend to decrease the equipment weights. New structural materials will provide further weight savings in the areas of surface controls, hydraulics, pneumatics, and passenger accommodations. The overall trend for the future will show a decrease in fixed-equipment weights.

The list below indicates the savings used for the 1985 equipment weights.

Instruments	20%
Surface controls	10%
Hydraulics	25%
Pneumatics	No factor applied
Electrical	30%
Electronics	35%
Flight provisions	20%
Passenger accommodations	5 lb (2.27 kg)/passenger
Cargo handling	No factor applied
Emergency equipment	No factor applied
Air conditioning	10%
Anti-icing	10%

Weight prediction variables.–The following list of variables is used in the weight methods to analyze the various intraurban V/STOL concepts.

- Wing–Wing area; gross weight; wing sweep; taper ratio; thickness/chord ratio; dead weight relief factors for fuel, engines, etc.; fatigue allowance; high-lift flap systems; and augmentation allowance

- Empennage—Horizontal and vertical tail areas, gross weight, design dive speed, surface sweep, taper ratio, thickness/chord ratio

- Fuselage—Wetted area, weight of contents, body length, number of door cutouts, design dive speed, and pressurization

- Landing gear—Gross weight and frequency of landings

- Propulsion—Length and diameter of engine, sea level static thrust, and fuel capacity

- Fixed equipment—Gross weight, electrical requirements, airplane geometry, and interior arrangement

Weight uncertainty.—The empirical methods used in this analysis have a statistical accuracy of approximately ±10% on operating empty weight (OEW) for the commercial airplane family. The items that build up to an OEW could quite possibly be much greater than the above tolerance value.

Consistency in weight trends for parametric studies is maintained, however, because basic weight equations reflect weight variations due to scaling of geometry, thrust, wing loading, etc. Resulting calculated operating empty weight trends are therefore consistent for each configuration type and type comparison.

6.1.6 Avionics and Flight Operations

The advanced technology of avionics and flight operations assumes an essentially new use of the operating environment for the time periods considered in this study. This section will describe the approach aids, navigation, and communication technologies required to support the intraurban transportation aircraft in the postulated 1975-1985 ATC systems, as they differ from the technology levels described in reference 19.

6.1.6.1 Approach and Landing Aids

The approach and landing phase of the intraurban aircraft operations will be accomplished with the use of the microwave landing system. This system is currently under study by the Radio Technical Communication for Aeronautics, Special Committee 117 (SC-117). The task of SC-117 has been to develop a precision guidance system concept for approach and landing and an associated signal structure. The current ILS system, used in airports in the United States since 1939, works well in many circumstances and should be adequate for continuing applications such as a low-cost aid for general aviation for many years. However, the ILS is not protected by IAO agreement past 1975. The new microwave system offers new capabilities that will include:

- Guidance service for fully automatic touchdown without dependence on other sensor systems

- Broad coverage in both azimuth and elevation for automatic turn-on to final approach, controlled departure, and missed approaches
- Proportional coverage over wide angles for curved approach paths and glidepaths
- Relative freedom from siting effects
- Small size for equipment to meet military needs, including aircraft carriers and certain needs of general aviation
- Potential for low-cost ground and airborne equipment for small airports and general aviation use.

These features make the microwave landing system(MLS) especially attractive for STOL use in an intraurban transportation situation. The MLS will provide a signal to the aircraft that will permit the aircraft to fly a completely programed curvilinear (or straight) path from initial signal intercept to touchdown. This signal will be composed of coded radiation from two scanning beam antennas and a distance measuring device. The signal will be processed by an onboard digital flight control computer to provide guidance information to the aircraft flight control system.

6.1.6.2 Navigation

The intraurban aircraft will navigate by means of an inertially aided radio navigation system. This system, using the VOR/DME signal environment while en route, will provide an area navigation capability that will justify reduced longitudinal en route spacings. The VOR/DME stations currently available and operating in the San Francisco Bay area will provide adequate signal coverage for the en route portions of the intraurban route system while the microwave landing system will provide the navigation signals required for terminal area approaches. Figure 9-3 illustrates the major units of the aircraft navigation system.

6.1.6.3 Communications

It is expected that the digital data link will largely replace VHF voice communications for the prime communications functions in intraurban systems. As shown in figure 6-22, the data link will provide the necessary communications for air traffic control time-synchronized operations as well as the surveillance function required where the terminal area or en route surveillance radar system has neither the desired cover nor the accuracy.

6.2 CONFIGURATIONS

6.2.1 Design Ground Rules

The following basic ground rules have been used for the vehicle designs and weight estimates. Sensitivity studies have been made to determine the effect of variations in some of these ground rules on the transportation system. The changes made for the sensitivity studies in section 6.2.7 are outlined below.

- Design payload
  - Passengers 50, 100, and 150 at 200 lb (91 kg) each
  - Baggage volume–5 cu ft (0.14 cu m)/passenger
  - Crew–two

- Interior layout
  - Compartments 5-, 6-, 7-abreast (back to back)
  - Seat width–20 in. (0.508 m)
  - Compartment length–80 in. (2.03 m)
  - Number of doors–two per compartment (30 by 72 in.–0.76 by 1.83 m)
  - Stewardesses–none
  - Baggage volume:
    - 50 passengers–250 cu ft (7.08 cu m)
    - 100 passengers–500 cu ft (14.16 cu m)
    - 150 passengers–750 cu ft (21.24 cu m)

- Air conditioning
  - Pressurization–1.0 psi (703.1 kg/sq m)

- Fixed equipment
  - APU–none
  - Galleys–none
  - Toilets–none
  - Seats–nonreclining, lightweight
  - Passenger service unit–none

6.2.2 Mission Ground Rules

The ground rules used in the initial phase of the study divide the mission into a series of increments. The increments used are:

- Taxi-out (fuel and time; no distance credit)

- Takeoff and climb to 1500 ft (457 m) (fuel and time; no distance credit)

- Climb from 1500 ft (457 m) to cruise altitude (fuel, time, and distance)

- Acceleration (fuel, time, and distance)

- Cruise (fuel, time, and distance)

- Descent from cruise altitude to 1500 ft (457 m) (fuel, time, and distance)

- Approach and landing (fuel and time; no distance credit)

- Taxi in (fuel and time; no distance credit)

- Reserves
- Field length 2000 ft (610 m)

The increment of time used during each taxi-out and taxi-in has been assumed as 30 sec for the VTOL and 1 min for the STOL. The mission chosen for design purposes is 100 nmi (185 km) at a cruise altitude of 5000 ft (1524 m). These are not considered to be optimum cruise conditions but are typical of what might be expected in system operation. Reserves are assumed to be 20 min cruise for the VTOL airplane and 30 min cruise for the STOL airplanes.

The period of time involved during the boarding phase is to be treated as a variable.

6.2.3 Configuration Philosophy and Description

6.2.3.1 Configuration Philosophy

As pointed out in the earlier sections, these very-short-range airplanes are insensitive to the usual design parameters, i.e. range factor, structural design techniques, etc. However, the overall system is very sensitive to turnaround time, reliability, and airplane price. For instance, with an average block time of 10 min, if the turnaround time is increased from 5 to 10 min, the overall utilization of the airplane falls to 75% of its former value. This perturbation in turnaround time not only increases the direct operating costs (DOC) but requires that the fleet size and the number of gates at the STOLport be increased by 33% to carry the same passenger volume.

Because of the sensitivity to turnaround time and reliability, the primary goals in developing the airplane configurations have been ease of access to the passenger cabin and simplicity of design, both as a means of reducing manufacturing costs and reducing maintenance costs. Turnaround time can be minimized if

- Passengers have easy access to and from the cabin
- Cabin has many doors
- Engines are operated continuously
- Refueling can take place at each stop on a semiautomatic basis.

The above design goals are best met with a high wing, T-tail configuration in which the engines are located in or above the plane of the wing. This type of configuration places the cabin floor close to the ground and leaves an unobstructed area surrounding the cabin free for boarding ramps or elevators.

The other design goals of reliability and low price are best met by simplifying the basic configuration and design details. For instance, manufacturing costs can be lowered by

- Use of constant sections
- Multiple use of parts and assemblies
- Minimization of the amount of machined skins
- Elimination of exotic materials

To comply with the above techniques of cost reduction, a constant-diameter body with identical frames, doors, and seats and an untapered wing and horizontal tail were chosen for each configuration. The untapered wing also simplifies the method of flap operation. The landing gear is semiretracting in that the oleo is sucked up after takeoff leaving the lower portion of the wheels exposed.

The 1975 airplanes lend themselves to conventional skin/stringer or bonded-honeycomb-type construction. Since the airplanes are insensitive to aerodynamic cleanliness, the skin tolerances can be relaxed to use either type of construction to best advantage.

Although the fiber composite materials are exotic for the 1975 airplanes and will not be used in that time period, it is assumed that, by 1985, the fiber composites will be readily available with production of the fibers in sufficient quantity to support large-scale airplane manufacture.

The airplane sizing, which includes weights and performance estimates, is performed using a computerized airplane design program.

6.2.3.2 Interior Layout

The largest term in the ground time buildup is passenger debarking and embarking. To minimize this time, the approach taken was to provide the passengers with a large number of doors and locate them within the airplane so that they are able to reach the doors easily. The simplest layout to accommodate these design features is the "European train" concept in which the passengers are seated face-to-face across the airplane with an aisle between them and doors at both ends of the aisle, see figure 6-23.

The actual passenger totals for the three interior layouts were 49, 95, and 153 passengers for the jet-powered airplanes and 50, 100, and 150 for the rotary wing machines. The passenger baggage is containerized and located on the same level as the passengers.

6.2.3.3 Alternate Interior Layout

Two alternate interior layouts were used for the gate time sensitivity study. The first of the alternate interiors, type II, is shown in figure 6-24. Basically, the type I interior has been modified by joining two cabins together through the removal of two seats. Using one door

for loading and one for unloading per cabin, effectively halves the number of doors required for each airplane. The number of passengers for each of the type II airplanes are now 53, 109, and 155.

The type III interior, which is similar to a conventional airplane interior, is shown in figure 6-25. The layouts have been based on the 50-passenger configuration, and its estimated turnaround time of 5 min. The number of aisles and doors have been chosen to make the 100- and 150-passenger airplanes comparable to the 50-passenger airplane in turnaround time. The 150-passenger airplane cabin had to be resized to accommodate the two aisles. The body diameter was increased from 161.5 to 174 in. (4.10 to 4.42 m) This increase in body size makes an underfloor cargo hold feasible and results in a change of trend in the airplane weights, see section 6.2.6.

The actual passenger numbers for the type III interior airplanes are 52, 101, and 150.

6.2.3.4 STOL Configurations

1975 augmentor wing STOL.—The 1975 augmentor wing design is based on the current Boeing conversion of the de Havilland Buffalo for NASA. In the concept, the air supply from the two engines is kept separate and is divided equally between the two wings (see fig. 6-26). The air from each engine is divided at the rear face of the low-pressure compressor and led through two ducts to each wing. The air is ejected from each duct through an individual nozzle so that the air supply from each engine is maintained in a separate duct system right through the nozzle. The air supplies from each engine mix within the flap where they also mix with the ambient air.

Since simplicity and not high propulsion efficiency is striven for, the augmentor flap is used for cruise as well as takeoff and landing. The cruise configuration of the flap is 0° deflection with the upper and lower flap sections closed slightly from the takeoff configuration. By eliminating the requirement for individual cruise nozzles for each engine and by providing duct separation, it is possible to build a valveless system. Loss of one engine neither unchokes the nozzle nor produces an imbalance of air supply between each wing.

The thrust for airplane propulsion is distributed along the trailing edge of the wing at all times with only a small percentage of the residual thrust being produced by the primary section of the engine. The most convenient engine location to provide access to the wing interior, simplifying the ducting system and providing an uncluttered exterior to ease passenger access, is the wing tip, see figure 6-27.

The problem of providing sufficient room within the wing for the ducting system is eased by using the same wing loading as the 1975 conventional STOL, 55.0 psf (268 kg/sq m). The unaugmented T/W required for takeoff is taken from figure 6-4 as 0.39. To accommodate the ducting system, the basic wing thickness-to-chord ratio has been increased to 21% and the rear spar has been moved forward to the 45% chord position. The flap chord is 25% of the wing chord. One parameter that has a strong effect on the wing chord geometry is the mixing ratio between the ambient air and the ducted air in the cruise configuration. No data are available on this subject at the present time. To overcome this shortcoming, two values of mixing ratio at either end of the anticipated range have been taken, and the wing

chord geometry has been developed for both configurations in figure 6-28. These two examples show that, in both cases, the ducting can be accommodated (between the rear spar location, at approximately the 45% chord point, and the flaps) with space available for the structure and control runs.

The estimates of cruise performance were based on the assumption that the flap augmentation was balanced out by the ram drag of the flap. Consequently, the propulsion system could be treated as a normal bypass engine with a large total pressure loss in the bypass system. The assumption may not be strictly true but is the best approximation that can be made at the present time.

The $C_{L_{MAX}}$ (FAR) is 6.20, and the landing field length can be met with a braking level of 0.25 g. A low braking level such as this is advantageous in increasing brake and tire lives.

Estimates show that a 50-fps (15.2 m/sec) sharp-edge gust at sea level, when cruising at M = 0.5, will induce a load factor of n = 3.1 g. This load exceeds the design load factor of the airplane which is 2.5 g. Under these conditions, the airplane would be restricted to a cruise speed of M = 0.4. Due to the above loading conditions, and because of the uncomfortable ride characteristics, it is considered to be necessary to include a gust alleviation device that would assist in maintaining the cruise speed and raising the structural fatigue life.

1985 augmentor wing STOL.—The primary differences between the 1975 and 1985 augmentor STOL airplanes are in the duct and nozzle designs and in the airframe structure, see figure 6-29. The 1985 airplane uses a single duct with variable-area nozzles to prevent the throats becoming unchoked during single-engine operation. The duct design also requires a valve between each engine and the duct to block the end of the duct in the event of an engine failure. By using the single large manifold duct, the engine pressure ratio can be reduced to 2.5, thus reducing the noise level of the propulsion system.

The augmentor flap system on this airplane is capable of generating a $C_{L_{MAX}}$ (FAR) of approximately 10.0, allowing the wing loading to be raised to 80 psf (390 kg/sq m). The unaugmented thrust loading necessary to meet the takeoff requirements is a T/W of 0.46. The thickness-to-chord ratio is increased to 27%, but, because of the truncation of the trailing edge, the aerodynamic thickness-to-chord ratio (t/c) is only 21%. The landing requirements dictate a braking level during rollout of 0.25 g.

6.2.3.5 VTOL Configuration

1975 tandem rotor helicopter.—The 1975 helicopter (fig. 6-30) is a four-engine tandem-rotor design with 20% rotor overlap, the maximum allowed by noise considerations. The analysis is benefiting from the Boeing heavy-lift helicopter effort. The aircraft are sized for two hover conditions: first a 90° F (32° C) day with cruise at normal rated power, and second, installed horsepower such that hover can be maintained with one engine inoperative (OEI).

Flight control movements of the collective control, cyclic control, and directional pedals are transmitted mechanically through a system of bell-cranks and push and pull

linkages to a mixing unit where the control movements are coordinated to give the correct cyclic and collective pitch to the rotor blades through hydraulic actuators positioned near the swashplates. The following controls are provided:

- Roll—Lateral cyclic pitch
- Yaw—Differential lateral cyclic pitch
- Pitch—Differential collective pitch
- Height—Collective pitch

The system is mechanical to the control valves of the hydraulic boost actuators and is, in all respects, similar to the latest control arrangement of present tandem-rotor helicopters. A dual stability augmentation system automatically maintains stability in roll, pitch, and yaw. The SAS has limited authority and may be overtaken by pilot control in any emergency situation.

The rotors are four bladed and fully articulated. The blades were considered to be of the advanced geometry blade (AGB) configuration with respect to taper, thickness, and twist. A double-spar arrangement was selected as optimum in strength to weight (V_{Tip} = 750 fps—228.6 m/sec).

The helicopter hubs are of the elastomeric type with maximum use of titanium in all possible applications.

The four engines are mounted in podded nacelles cantilevered outboard and forward of the aft pylon. Each engine drives into a nose bevel gear box that transmits engine power to the longitudinal shaft through a transverse shaft for the single main distribution gear box. A separate short transverse shaft exists for each engine. An overrunning clutch is installed at the inboard end of each transverse shaft. The clutch provides a positive drive connection for the transmission of power and permits an automatic disconnect of any engine that becomes damaged or inoperative. The longitudinal shaft transmits power to the forward and aft main rotor gear boxes that consist of a bevel and double planetary reduction to the rotor shaft. A small single (1:1 ratio) gear set is included in the main distribution gear box. A schematic of the system is shown in figure 6-31.

1985 Helicopter.—The 1985 helicopters will be similar in arrangement to the 1975 helicopter, being somewhat smaller for each passenger capacity. The analysis uses the previous NASA study of the 1985 time period (ref. 1) for a data base.

The flight controls of the helicopter of the 1985 time period will have fly-by-wire (triple redundancy) control input and electronic mixing and phasing to the electrically operated actuator control valves. Actuation of the rotor blades and auxiliary controls will be hydraulic and pneumatic, as shown for the 1975 time period above, with appropriate use of advanced system techniques.

The blade planform is of the AGB type, as above, with some advantage assumed in weight due to the probable development and use of high strength-to-weight ratio materials and advanced construction techniques (V_{Tip} = 750 fps–228.6 m/sec).

1985 Tilt Rotor.–The tilt-rotor airplane (fig. 6-32) represents the latest wing/nacelle design that has evolved from extensive study at Boeing. The tilt-rotor airplanes are being sized using the VASCOMP II program (developed for NASA under contract NAS2-3142). A disc loading of 15 psf (73.2 kg/sq in) is being used.

Control in the conventional mode is provided by the elevator, rudder, and ailerons. In hover and transition, control is provided in the following manner:

- Roll–Differential collective pitch
- Pitch–Longitudinal cycle pitch
- Yaw–Differential longitudinal cyclic pitch or a combination of differential longitudinal cyclic pitch plus differential nacelle tilt
- Height–Collective pitch

An automatic sequencing and phase transition from hover flight to conventional flight controls will be referenced to forward speed and nacelle angle. Wing flaps are programmed with nacelle tilt. Mixing and phasing of controls during hover and transition will be controlled electrically. A fly-by-wire system of control inputs will be used up to the electrically actuated actuator control valves. The actuators will be hydraulically powered. Limited-authority SAS maintains stability in hover and transitional flight.

The three-bladed rotor is of the hingeless (rigid) type. The blades are considered to be made of composite materials allowing optimization of planform, thickness-to-chord ratio, taper, and twist. It was assumed that a blade tip section would be available with a tip Mach number limit of 95% (V_{Tip} = 850 fps–259 m/sec).

Two engines are mounted in each tilting nacelle at the wing tip. Each engine shaft extends forward through an overrunning clutch to a spur gear input to the rotor gear box. The power is transmitted through the spur reduction and a double planetary reduction to the rotor shaft. A power takeoff from the rotor gear box ring gear is transmitted through a short shaft to a bevel set that, in turn, transmits power to the cross shaft that is concentric with the tilting axis and permits equal distribution of power in case of engine failure or a partial power condition due to damage. A schematic of the system is shown in figure 6-33.

6.2.4 Characteristics Summary of Airplanes

Details of the geometric characteristics, weight breakdowns, and other pertinent data for the baseline airplanes are presented in this section. The overall geometric, weights. and performance data for the airplanes are presented in tables 6-4 through 6-8, and the weight statements are presented in tables 6-9 through 6-13.

The above data are presented in a comparative form, with plots of takeoff gross weight, operational empty weight (OEW) fraction, and payload fraction versus passenger capacity, for all the airplanes in figures 6-34, 6-35, and 6-36. The basic conclusions drawn from these comparisons are that:

- STOL airplanes are lighter than VTOL airplanes.
- OEW fractions vary between 50% and 70%.
- Payload fractions vary between 25% and 40%.

6.2.5 Airplane Performance Summary

The curves of block time and fuel used versus range for each of the baseline airplanes is presented in figures 6-37 through 6-41. A comparison of the fuel used and block times versus range for each of the 100-passenger airplanes is presented in figures 6-42 and 6-43. A quick survey of these data indicates that the 1975 helicopter burns more fuel than the other airplanes and that the block time of the helicopter is considerably higher than the other vehicles.

6.2.6 Airplane Sensitivities Studies

The following studies were performed to determine the sensitivity of various airplane characteristics to perturbation of various mission and design parameters. The results of the economic analyses for all sensitivity studies, except the number of hops, are presented in section 11.5.

6.2.6.1 Design Field Length

The investigation of the field-length variation of the 1975 and 1985 augmentor wing airplanes was performed using the 95-passenger configuration as the baseline. The field-length variation was achieved by holding the wing loading constant for each of the technology years and allowing the thrust loading to vary. The basic results of the study are shown in figures 6-44 and 6-45 where fuel burned, empty weight, and gross weight are plotted against field length. The sensitivities of the design parameters to field length, evaluated at the 2000-ft (610-m) field length, are tabulated in table 6-14.

The performance data are presented in figures 6-46 and 6-47, where the fuel burned and block time for each field length are plotted against range. A weight statement for each of the airplanes is given in tables 6-15 and 6-16.

6.2.6.2 Thrust Loading

The field length data have been replotted to show the thrust loading sensitivities, see figure 6-48 and 6-49. The values of the sensitivities are listed in table 6-17.

The results show that the airplane characteristics are relatively insensitive to changes in thrust loading, which is the general conclusion of the sensitivity analysis of section 6.1.1.

6.2.6.3 Design Cruise Mach Number

The sensitivities of the airplanes to design cruise Mach number have been investigated using the 1975 and 1985 augmentor wing STOL baseline 95-passenger airplanes. The thrust loadings and wing loadings for the 2000-ft (610 m) field length have been used for each airplane, and only the cruise Mach number has been varied.

The results of these sensitivity studies are presented in figures 6-50 and 6-51, and the weight statements are in tables 6-18 and 6-19. The figures show that the gross weights and operational empty weights are relatively insensitive to design cruise Mach number over the range investigated. The fuel burned shows a minimum at approximately M = 0.4, and the overall maximum variation in fuel burned is approximately 20%. For the Mach number range studied, the block times were reduced from 0.575 to 0.342 hr at M = 0.6, a reduction of 40%.

6.2.6.4 1985 Tilt-Rotor VTOL Disc Loading

The disc loading of the tilt-rotor VTOL was varied between 11 and 19 psf (53.7 and 92.8 kg/sq m). The result of increasing the disc loading is to increase the power requirements and ultimately the cruise speed capability. Hence, the increase in disc loading results in an increase of gross weight, see figure 6-52. The weight statements are given in table 6-20.

6.2.6.5 Gate Time Sensitivity

The gate time sensitivity has been performed by comparing the baseline airplane, which is designed around the type I "European train" interior layout described in section 6.2.3.2, with airplanes designed around the type II and III interior layouts described in section 6.2.3.3. The 1975 and 1985 augmentor wing airplanes were chosen as the basic airplanes for use in the analysis.

The plot of gross weight versus passenger capacity is presented in figure 6-53 for each type of interior and the two technology levels. The airplanes with the type I and II interiors tend to fall on the same curve, but the conventional type III interior produces a 5% higher gross weight at the 50- to 100-passenger capacities. However, the type III, 150-passenger airplane has a 2%-3% lower gross weight due to the overall lighter body. The weight statements for the airplanes are presented in tables 6-21 through 6-24.

The nominal gate times that each of the types of interiors represent are: type I, 3 min; type II, 4 min; and type III, 5 min.

6.2.6.6 Low-Maintenance Engine

The sensitivity of the augmentor wing STOL to use of the low-maintenance and low-cost engine has been investigated, and the airplane has been resized to reflect the changes in the powerplant characteristics.

The penalties associated with the low-maintenance and low-cost engine are estimated to be:

- A 15% increase in engine weight
- A 10% increase in sfc

The impact of the powerplant change on the 49-passenger airplane can be noted from the weight statement of table 6-25. The operational empty weight increased by 700 lb (317 kg) or 2.9%.

The overall effect of the engine change on the direct operating costs can be seen from figure 6-54. The increases in sfc and engine weight of 10% and 15%, respectively, produce an increase of 3% in the DOC. However, a 20% reduction in engine price reduced the DOC by 1.7%, and a 20% reduction in engine maintenance costs reduced the DOC by a further 4.3%.

From the above analysis it can be seen that, if a choice has to be made between reducing initial engine cost or reducing the engine maintenance costs, the choice would be to strive to reduce the maintenance costs. Furthermore, the reduction in maintenance costs is also reflected in the reduction in maintenance facility requirements, which will assist in reducing the indirect operating costs. No estimate was made of the change in maintenance facility requirements.

6.2.6.7 Unrefueled Hops

The sensitivity of designing the four basic airplanes to perform a series of unrefueled 20-nmi (39-km) hops is presented in figure 6-55. The number of hops were varied from one to seven, with a 4-min gate time after each hop. The percentage variation in gross weight per hop for each type of airplane is:

1975 STOL	1985 STOL	1975 Helicopter	1985 Tilt Rotor VTOL
3.0%	2.1%	1.8%	1.3%

6.2.7 Description of Competing Configurations

The first phase of the study compared many possible airplane concepts that could be suitable for an intraurban transportation system. These airplanes were eliminated from the study at the end of phase I. A brief summary of the competing airplanes, their characteristics, and the reasons for which they were dropped from the study follows.

6.2.7.1 1975 and 1985 Conventional STOL

The design parameters of the conventional STOL are dependent on the high-lift system used. To maintain the current design philosophies of simplicity and reliability, a double-slotted Fowler flap with a slotted aileron were chosen. A wing section with a t/c of 0.15 and a blunt leading edge eliminated the need for leading edge devices. The $C_{L_{MAX}}$ (FAR) for

the configuration is approximately 3.60. Assuming an average deceleration of 0.45g in the landing rollout, a wing loading of 55 psf (268 kg/sq m) is required to meet the 2000-ft (610 m) field length, see figure 6-56. The thrust loading required to meet the takeoff requirements is T/W = 0.48.

The final configuration and engine location selection is the result of satisfying the following criteria:

- Keep engines clear of the cabin side to permit cabin access.
- Keep engines close to the airplane centerline to minimize yawing moments due to single-engine operation.
- Minimize the propulsion/wing-lift interaction to avoid induced rolling moments due to loss of an engine.
- Minimize loss of wing lift due to nacelle/flap interaction.
- Keep engines close to the cg to avoid a close-coupled configuration.

Economically, there was little difference between the conventional and the augmentor wing STOL airplanes. It was believed that either of the two concepts was suitable for more-detailed analysis, and the major results of the study would not be affected by the choice.

6.2.7.2 1985 Ejector Wing VTOL

During the evaluation of various jet-powered vertical-takeoff aircraft, the operational ground rules were made that:

- All engines must be operated continuously.
- Loss of one engine must not result in a loss of control or hover capability.

The configuration that evolved is based on a tilt-wing ejector flap, see figure 6-57. The ejector flap differs from the augmentor flap in that the ejector flaps are used as control and thrust augmentation devices and not as a means of developing high lift levels. During hover, the ejector flap provides both yaw and roll control; pitch control is developed through attitude control thrusters in the nose and tail of the body. Four engines are installed for safety with a combined installed thrust-to-weight ratio of unity. The excess thrust over weight is obtained through augmentation in the ejector. It is estimated that the augmentation during hover should provide an additional 40% thrust. In the event of an engine failure, the total thrust-to-weight ratio would still be greater than 1.05, and control would be maintained by ducting air from one wing to the other. The crossover duct has been sized for the worst possible condition of failure of two engines on one wing. In this event, the equivalent of one engine's air supply would be ducted to the other wing and, although the airplane would be incapable of hovering, it would be capable of a conventional landing.

The duct system requires valves for control of air supply in the event of engine failure. These include valves between each engine and the duct and along the slot. Other valves will be required to operate the attitude-control thrusters.

Structurally, the manifold duct acts as a rear spar and the pivot point for the wing. The second duct is accommodated in the wing box region behind the front spar. Due to this use of available space, the fuel tanks are located in the wing leading edge.

The 1985 ejector wing VTOL was dropped from the study because of its inability to compete economically with the other airplanes.

6.3 FLIGHT SAFETY

The purpose of evaluating the flight safety data is to develop the costs associated with insuring the airplane fleet and to compare the passenger safety with other modes of travel. The analysis shown below is based on current trends extrapolated to the 1980-1990 time period. Due to the quantity of data available and because the data are being used to generate information on a different mode of air travel, the extrapolations are more than normally prudent. For this reason, the results should be treated as trends rather than as firm values.

A survey of all free-world jet fleet accidents over the period 1959 to 1970 shows that the majority of accidents (54.5%) occurred in the final portion of the flight profile, see figure 6-58. Of the remaining 45.5% of the accidents, 31.9% occurred during taxi, takeoff, and climb. The intraurban flights have essentially no cruise portion to the flight profile. Since the majority of accidents occur during the noncruise region, the flight safety statistics are evaluated on a departure basis and not on a passenger-mile basis.

One problem associated with evaluating the safety record of the current jet fleets is that the landing field lengths for these airplanes are in the range of 5000 to 7000 ft (1524 to 2134 m), and the airplanes are often landing on 10 000-ft (3048 m) runways. In other words, there is a large margin available for touchdown dispersion. This dispersion margin will not be available to STOL airplanes, and, to minimize the effect of the constraint, full use must be made of automated landings, low approach speeds, and steep glidepaths. The estimated fatal accident rate is derived from a projection of fatal accident rate correlated with time.

The trend in U.S. fatal accidents per million departures versus time is shown in figure 6-59. The data for the period 1959 to 1969 have been used to extrapolate to the intraurban system time periods of 1980 and 1990. The trend indicates a fatal accident rate of 0.13 million departures by 1980.

Previous studies of the effect of approach speed on the accident rate have indicated that a trend exists in which the reduction in approach speed tends to reduce the accident rate. However, the quantity and quality of data available are insufficient to project a value for accident rate at the approach speeds expected of the intraurban STOL.

To be more conservative and negate some of the errors due to extrapolation, an accident rate of 0.5 per million landings has been used to estimate insurance costs. This is 70% of the current DC-9 accident rate. Using the 1980 STOL base case, this would amount to a long-term average of 0.345 accidents per year.

Comparable data for the helicopter is sparse and does not form a good statistical basis. However, the data available for the period 1960 to 1965 indicates a fatal accident rate of 4.05 per million departures, which is comparable with the jet air transport fatal accident rate for the same period.

An attempt has been made to compare rail, bus, and air transport in order to show their relative safety. The first correlation is shown in figure 6-60 where the fatalities per 100 million passenger miles are compared annually. Air transport displays a vast improvement in time and is now comparable with bus transportation, which has displayed no improvement with time. The rail transportation data are erratic, but the upper bound shows a good improvement with time. The erratic behavior is probably due to the reduced data sampling incurred from reduced passenger operations.

When total fatalities are compared, the results shed more light on the relative safety of operations. The total number of passenger fatalities over the period 1950 to 1969 for U.S. route air carriers is 2573, bus is 2090, and rail is 765. However, other fatalities involving rail transportation (railroad crossings, etc.) contributed another 46,000 fatalities. The number of other fatalities related to U.S. route air carrier operations were 73 (not onboard the commercial aircraft) for this same time period. No figure was available for bus-related fatalities. The accidental fatality rate for the automobile passenger, which is an order of magnitude higher than the other modes of travel, has shown a slight improvement in the same time period.

To simplify analysis of the automobile fatalities and so determine the impact of the intraurban system on the overall accidental fatalities, the number of fatalities per 1000 vehicles registered has been developed, see figure 6-61. These statistics are available for the period 1915 to 1969. Extrapolating the upper and lower boundaries of the data variations to 1980 yields a fatality rate of approximately 0.3 to 0.4 per 1000 vehicles registered.

The 1980 STOL base case projects a total of 48 551 passengers per day using the intraurban system, of which 60% would sell their automobiles. Using a mean fatal accident rate of 0.35 per 1000 vehicles registered, this would amount to a saving of 10 lives per year. By comparison, the assumed intraurban system fatality rate would yield an average of 4.7 fatalities per year, or a net saving of five lives per year.

Other methods of predicting relative accident rates in 1980 would yield slightly varying numbers, but the importance here is that the aircraft system is still a safer mode of travel than the automobile, even at these very short ranges.

TABLE 6-1.—AUGMENTOR FLAP CYCLE AND NOISE PARAMETERS

Parameter	1975	1985
Fan pressure ratio	3.0	2.5
Bypass ratio	2.5	3.2
Turbine inlet temperature, °R (°K)	2800 (1550)	2800 (1550)
Primary jet velocity, ft/sec (m/sec)	700 (213)	700 (213)
Fan jet velocity, ft/sec (m/sec)	1400 (428)	1250 (380)
Fan tip speed, ft/sec (m/sec)	1350 (410)	1250 (380)

TABLE 6-2.—STUDY ENGINE PARAMETERS

Parameter	1975	1985
Reference engine	T64/S5C-1	GE1/S1A—modified
shp/W_a (std day), hp/lb/sec (watt/kg/sec)	174 (286000)	218 (358500)
Turbine inlet temperature, °F (°K)	2200 (1480)	2400 (1590)
Pressure ratio @ 95° F (308° K)	15.7	12.74
sfc, lb/hp-hr (kg/watt hr)	0.468 (0.000284)	0.410 (0.000249)
Power/weight ratio (std day)	6.40	8.77

TABLE 6-3.—GRAPHITE/EPOXY COMPOSITE PROPERTIES—1985

Property	psi	N/m^2
Longitudinal tensile strength	250 000	17.2×10^8
Longitudinal tensile modulus	50×10^6	34.5×10^{10}
Longitudinal compressive strength	250 000	17.2×10^8
Transverse tensile strength	10 000	6.9×10^8
Transverse tensile modulus	1×10^6	69×10^8
Flexural strength (L/D = 32/1)	220 000	151×10^8
Flexural modulus (L/D = 4/1)	40×10^6	27.5×10^{10}
Short beam shear (L/D = 4/1)	16 000	11×10^8
Filament content by volume	60%	60%
Composite density	0.05 lb/in.^{3}	1380 kg/m^3

TABLE 6-4.—BASELINE AIRPLANES—1975 AUGMENTOR WING STOL

Airplane components	English units: Passengers 49	95	153	International system of units: Passengers 49	95	153	Units
	Wing dimensions			Wing dimensions			
Span, ft	63.6	81.1	99.6	19.38	24.72	30.36	m
Area, sq ft	675	1097	1654	62.71	101.91	153.66	m^2
Aspect ratio	6.0	6.0	6.0	6.00	6.00	6.00	—
Mean chord, ft	10.61	13.52	16.60	3.23	4.12	5.06	m
	Horizontal tail dimensions			Horizontal tail dimensions			
Span, ft	24.8	30.1	33.7	7.56	9.17	10.27	m
Area, sq ft	205	302	379	19.04	28.06	35.21	m^2
Aspect ratio	3.0	3.0	3.0	3.0	3.0	3.00	—
Mean chord, ft	8.26	10.04	11.24	2.52	3.06	3.43	m
	Vertical tail dimensions			Vertical tail dimensions			
Area, sq ft	124	184	222	11.52	17.09	20.62	m^2
Aspect ratio	1.0	1.0	1.0	1.0	1.0	1.0	—
	Body dimensions			Body dimensions			
Length, ft	61.0	86.0	111.7	18.59	26.21	34.05	m
Diameter, in.	130.5	145.0	161.5	3.31	3.68	4.10	m
	Weights			Weights			
OEW, lb	24 160	36 408	53 159	10 959	16 515	24 113	kg
Payload, lb	9 800	19 000	30 600	4 445	8 618	13 880	kg
Mission fuel, lb	1 717	2 660	3 872	779	1 207	1 756	kg
Reserve fuel, lb	1 441	2 282	3 347	654	1 035	1 518	kg
Maximum taxi GW, lb	37 118	60 350	90 978	16 837	27 375	41 268	kg
	Performance			Performance			
Field length, ft	2000	2000	2000	610	610	610	m
Range, nmi	100	100	100	185	185	185	km
Cruise speed, kn	325	325	325	602	602	602	km/hr
Cruise altitude, ft	5000	5000	5000	1 524	1 524	1 524	m
	Propulsion			Propulsion			
No. engines/SLST lb	2/7238	2/11 768	2/17 741	2/3283	2/5338	2/8047	kg

TABLE 6-5.–BASELINE AIRPLANES–1985 AUGMENTOR WING STOL

Airplane components	Passengers			Passengers			Units
	49	95	153	49	95	153	
	English units			International system of units			
	Wing dimensions			Wing dimensions			
Span, ft	47.4	60.4	74.0	14.45	18.41	22.56	m
Area, sq ft	375	607	913	34.84	56.39	84.82	m^2
Aspect ratio	6.0	6.0	6.0	6.00	6.00	6.00	–
Mean chord, ft	7.90	10.06	12.33	2.41	3.07	3.76	m
	Horizontal tail dimensions			Horizontal tail dimensions			
Span, ft	21.1	25.6	28.6	6.43	7.80	8.72	m
Area, sq ft	149	219	273	13.84	20.34	25.36	m^2
Aspect ratio	3.0	3.0	3.0	3.00	3.00	3.00	–
Mean chord, ft	7.05	8.54	9.54	2.15	2.60	2.91	m
	Vertical tail dimensions			Vertical tail dimensions			
Area, sq ft	96	142	170	8.92	13.19	15.79	m^2
Aspect ratio	1.0	1.0	1.0	1.0	1.0	1.0	–
	Body dimensions			Body dimensions			
Length, ft	61.0	86.0	111.7	18.59	26.21	34.05	m
Diameter, in.	130.5	145.0	161.5	3.31	3.68	4.10	m
	Weights			Weights			
OEW, lb	17 497	25 393	36 262	7 937	11 518	16 448	kg
Payload, lb	9 800	19 000	30 600	4 445	8 618	13 880	kg
Mission fuel, lb	1 421	2 198	3 207	645	997	1 455	kg
Reserve fuel, lb	1 259	1 989	2 937	571	902	1 332	kg
Maximum taxi GW, lb	29 977	48 580	73 006	1 360	22 036	33 116	kg
	Performance			Performance			
Field length, ft	2000	2000	2000	610	610	610	m
Range, nmi	100	100	100	185	185	185	km
Cruise speed, kn	325	325	325	602	602	602	km/hr
Cruise altitude, ft	5000	5000	5000	1 524	1 524	1 524	m
	Propulsion			Propulsion			
No. engines/SLST lb	2/6895	2/11 173	2/16 791	2/3127	2/5068	2/7616	kg

Table 6-6.– BASELINE AIRPLANES–1975 HELICOPTER

Airplane components	Passengers 50	Passengers 98	Passengers 150	Passengers 50	Passengers 98	Passengers 150	Units
	English units			International system of units			
	Rotor dimensions			Rotor dimensions			
Rotor diameter, ft	56.0	75.75	91.0	17.07	23.09	27.74	m
Total disc area, sq ft	4926	9012	13008	458	837	1208	sq m
	Body dimensions			Body dimensions			
Length, ft	64.0	82.5	100.75	19.51	25.15	30.71	m
Width, ft	10.0	13.33	15.0	3.05	4.06	4.57	m
Height, ft	10.83	10.82	11.67	3.30	3.30	3.56	m
	Weights			Weights			
OEW, lb	27 269	48 266	66 790	12 369	21 875	30 290	kg
Payload, lb	10 000	19 600	30 000	4 536	8 890	13 608	kg
Mission fuel, lb	1 850	3 350	4 660	839	1 520	2 114	kg
Reserve fuel, lb	1 170	2 180	3 000	531	989	1 361	kg
Maximum taxi GW, lb	40 289	73 756	104 450	18 275	33 456	47 378	kg
	Performance			Performance			
Range, nmi	100	100	100	185	185	185	km
Cruise speed, kn	172	172	172	319	319	319	km/hr
Cruise altitude, ft	*2000*	*2000*	*2000*	*610*	*610*	*610*	*m*
	Propulsion			Propulsion			
No. engines/shp	4/1844	4/3382	4/4708	4/1377	4/2520	4/3515	kW

TABLE 6-7.—BASELINE AIRPLANES—1985 HELICOPTER

Airplane components	Passengers			Passengers			Units
	50	98	150	50	98	150	
	English units			International system of units			
	Rotor dimensions			Rotor dimensions			
Rotor diameter, ft	56.0	75.75	91.0	17.07	23.09	27.74	m
Total disc area, sq ft	4 926	9 012	13 008	458	837	1208	sq m
	Body dimensions			Body dimensions			
Length, ft	64.0	82.5	100.75	19.51	25.15	30.71	m
Width, ft	10.0	13.33	15.0	3.05	4.06	4.57	m
Height, ft	10.83	10.82	11.67	3.30	3.30	3.56	m
	Weights			Weights			
OEW, lb	22 737	40 604	59 048	10 314	18 418	26 784	kg
Payload, lb	10 000	19 600	30 000	4 536	8 891	13 608	kg
Mission fuel, lb	1 375	2 540	3 760	624	1 152	1 705	kg
Reserve fuel, lb	1 030	1 930	2 850	467	875	1 293	kg
Maximum taxi GW, lb	35 142	65 074	95 658	15 940	29 517	43 390	kg
	Performance			Performance			
Range, nmi	100	100	100	185	185	185	km
Cruise speed, kn	214	214	214	396	396	396	km/hr
Cruise altitude, ft	2000	2000	2000	610	610	610	m
	Propulsion			Propulsion			
No. engines/shp	4/1648	4/3075	4/4555	4/1230	4/2295	4/3400	kW

TABLE 6-8.—BASELINE AIRPLANES—1985 TILT ROTOR

Airplane components	Passengers			Passengers			Units
	50	100	150	50	100	150	
	English units			International system of units			
	Wing dimensions			Wing dimensions			
Span, ft	51.1	67.0	79.1	15.58	20.42	24.11	m
Area, sq ft	408	758.0	1094	37.90	70.42	101.63	sq m
Aspect ratio	6.43	5.92	5.73	6.43	5.92	5.73	—
Mean chord, ft	7.98	11.35	13.84	2.43	3.46	4.22	m
	Horizontal tail dimensions			Horizontal tail dimensions			
Span, ft		34.0			10.36		m
Area, sq ft		247.0			22.95		sq m
Aspect ratio		4.75			4.75		—
Mean chord, ft		7.34			2.24		m
	Vertical tail dimensions			Vertical tail dimensions			
Span, ft		14.0			4.27		m
Area, sq ft		175.0			16.26		sq m
Aspect ratio		1.12			1.12		—
Mean chord, ft		12.91			3.93		m
	Body dimensions			Body dimensions			
Length, ft		88.7			27.04		m
Diameter, in.	130.5	145.0	161.5	3.31	3.68	4.10	m
	Weights			Weights			
OEW, lb	20 365	36 699	52 058	9238	16 647	23 613	kg
Payload, lb	10 000	20 000	30 000	4536	9072	13 608	kg
Mission fuel, lb	1 020	1 700	2 300	463	771	1043	kg
Reserve fuel	855	1640	2350	388	744	1066	kg
Maximum taxi GW, lb	32 240	60 039	86 708	14 624	27 234	39 331	kg
	Performance			Performance			
Field length, ft							m
Range, nmi	100	100	100	185	185	185	km
Cruise speed, kn	302	320	330	559	593	611	km/hr
Cruise altitude, ft	2000	2000	2000	610	610	610	m
	Propulsion			Propulsion			
No. engines/shp	4/1967	4/3668	4/5299	4/1468	4/2740	4/3955	kW

TABLE 6-9.—WEIGHT STATEMENT—1975 AUGMENTOR WING STOL BASELINE AIRPLANES

Airplane Components	Passengers					
	49	95	153	49	95	153
	lb			kg		
Wing	4 126	7 142	11 113	1 871	3 240	5 041
Horizontal tail	625	927	1 144	283	420	519
Vertical tail	377	559	669	171	254	303
Body	6 678	10 213	14 548	3 029	4 633	6 599
Main landing gear	722	1 148	1 752	327	521	795
Nose landing gear	211	252	496	96	114	225
Nacelle and strut	418	780	1 634	190	354	741
Total structure	13 156	21 022	31 357	5 968	9 536	14 224
Engine	1 857	3 507	6 108	842	1 591	2 771
Engine accessories	188	220	252	85	100	114
Engine controls	65	75	85	29	34	39
Starting system	78	78	78	35	35	35
Fuel system	214	314	410	97	142	186
Thrust reverser	130	257	384	59	116	174
Air ducting system	514	655	805	233	297	365
Total propulsion group	3 046	5 107	8 123	1 382	2 316	3 685
Instruments	424	436	453	192	198	205
Surface controls	625	891	1 172	283	404	532
Hydraulics	300	348	409	136	158	186
Pneumatics	138	203	285	63	92	129
Electrical	1 087	1 087	1 087	493	493	493
Electronics	691	775	886	313	351	402
Flight provisions	468	501	544	212	227	247
Passenger accommodations	2 706	3 974	6 042	1 227	1 803	2 741
Cargo handling	95	179	272	43	81	123
Emergency equipment	81	118	167	37	54	76
Air conditioning	364	477	650	165	216	295
Anti-icing	108	116	126	49	53	57
Auxiliary power unit	0	0	0	0	0	0
Community noise abatement	354	575	868	160	261	394
Total fixed equipment	7 441	9 681	12 961	3 375	4 391	5 879
Exterior paint	0	0	0	0	0	0
Options	0	0	0	0	0	0
Manufacturer's empty weight	23 643	35 810	52 441	10 724	16 243	23 787
Standard and operational items	517	599	718	234	272	326
Operational empty weight	24 160	36 408	53 159	10 959	16 515	24 113
Maximum zero fuel weight	33 960	55 408	83 759	15 404	25 133	37 993
Maximum taxi weight	37 118	60 350	90 978	16 837	27 375	41 268

TABLE 6-10.—WEIGHT STATEMENT— 1985 AUGMENTOR WING STOL BASELINE AIRPLANES

Airplane Components	Passengers					
	49	95	153	49	95	153
	lb			kg		
Wing	1 573	2 514	3 782	714	1 140	1 716
Horizontal tail	311	449	555	141	204	252
Vertical tail	202	292	344	92	132	156
Body	4 741	6 922	9 695	2 150	3 140	4 398
Main landing gear	642	1 019	1 552	291	462	704
Nose landing gear	186	222	436	84	101	198
Nacelle and strut	508	924	1 766	230	419	801
Total structure	8 164	12 342	18 130	3 703	5 598	8 224
Engine	1 694	2 964	4 638	768	1 344	2 104
Engine accessories	185	217	248	84	98	112
Engine controls	63	72	81	29	33	37
Starting system	78	78	78	35	35	35
Fuel system	214	314	410	97	142	186
Thrust reverser	161	320	479	73	145	217
Air ducting system	383	488	598	174	221	271
Total propulsion group	2 778	4 452	6 532	1 260	2 019	2 963
Instruments	336	344	355	152	156	161
Surface controls	496	754	1 025	225	342	465
Hydraulics	213	243	280	97	110	127
Pneumatics	117	171	238	53	78	108
Electrical	761	761	761	345	345	345
Electronics	432	476	533	196	216	242
Flight provisions	375	401	435	170	182	197
Passenger accommodations	2 385	3 498	5 326	1 082	1 587	2 416
Cargo handling	95	179	272	43	81	123
Emergency equipment	70	99	138	32	45	63
Air conditioning	325	429	586	147	194	266
Anti-icing	96	100	112	44	45	51
Auxiliary power unit	0	0	0	0	0	0
Community noise abatement	337	546	821	153	248	372
Total fixed equipment	6 038	8 000	10 882	2 739	3 629	4 936
Exterior paint	0	0	0	0	0	0
Options	0	0	0	0	0	0
Manufacturer's empty weight	16 980	24 794	35 544	7 702	11 247	16 123
Standard and operational items	517	599	718	234	272	326
Operational empty weight	17 497	25 393	36 262	7 937	11 518	16 448
Maximum zero fuel weight	27 927	44 393	66 862	12 668	20 137	30 329
Maximum taxi weight	29 977	48 580	73 006	13 597	22 036	33 116

TABLE 6-11.—WEIGHT STATEMENT—1975
TANDEM ROTOR HELICOPTER
BASELINE AIRPLANES

Airplane Components	Passengers					
	50	98	150	50	98	150
	lb			kg		
Rotor	3 873	7 484	10 922	1 757	3 395	4 954
Horizontal tail						
Vertical tail						
Body	6 435	10 080	13 290	2 919	4 572	6 028
Main landing gear } Nose landing gear }	1 315	2 335	3 265	596	1 059	1 481
Nacelle and strut	725	1 267	1 727	329	575	783
Total structure	12 348	21 166	29 204	5 601	9 601	13 247
Engine	940	1 944	2 892	426	882	1 312
Engine accessories	295	546	783	134	248	355
Engine controls						
Starting system						
Fuel system	483	661	812	219	300	368
Thrust reverser						
Drive system	4 027	8 353	12 671	1 827	3 789	5 748
Total propulsion group	5 745	11 504	17 158	2 606	5 218	7 783
Instruments	265	265	265	120	120	120
Surface controls	1 973	3 328	4 595	895	1 510	2 084
Hydraulics	245	265	275	111	120	125
Pneumatics						
Electrical	775	875	930	352	397	422
Electronics	750	750	750	340	340	340
Flight provisions	220	220	220	100	100	100
Passenger accommodations	2 275	4 500	6 150	1 032	2 041	2 790
Cargo handling						
Emergency equipment	135	135	135	61	61	61
Air conditioning	750	1 500	2 250	340	680	1 021
Anti-icing	70	70	70	32	32	32
Auxiliary power unit						
Miscellaneous accommodations	1 198	3 128	4 268	543	1 419	1 936
Total fixed equipment	8 656	15 036	19 908	3 926	6 820	9 030
Exterior paint	0	0	0	0	0	0
Options	0	0	0	0	0	0
Manufacturer's empty weight	26 749	47 706	66 270	12 133	21 639	30 060
Standard and operational items	520	520	520	236	236	236
Operational empty weight	27 269	48 226	66 790	12 369	21 875	30 296
Maximum zero fuel weight	37 269	67 826	96 790	16 905	30 766	43 904
Maximum taxi weight	41 000	75 000	106 150	18 598	34 020	48 150

TABLE 6-12.—WEIGHT STATEMENT—1985
TANDEM ROTOR HELICOPTER
BASELINE AIRPLANES

Airplane Components	Passengers					
	50	98	150	50	98	150
	lb			kg		
Rotor	3 719	7 252	10 896	1 687	3 290	4 942
Horizontal tail						
Vertical tail						
Body	4 440	6 970	9 265	2 014	3 162	4 203
Main landing gear / Nose landing gear	1 155	2 065	2 995	524	937	1 358
Nacelle and strut	552	980	1 416	250	444	642
Total structure	9 866	17 267	24 572	4 475	7 832	11 146
Engine	738	1 562	2 502	335	706	1 135
Engine accessories	208	372	560	94	169	254
Engine controls						
Starting system						
Fuel system	371	492	618	168	223	280
Thrust reverser						
Drive system	3 656	7 785	12 352	1 658	3 531	5 603
Total propulsion group	4 973	10 211	16 032	2 256	4 632	7 272
Instruments	211	211	211	96	96	96
Surface controls	1 948	3 344	4 759	884	1 517	2 159
Hydraulics	184	199	206	83	90	93
Pneumatics						
Electrical	543	612	651	246	278	295
Electronics	490	490	490	222	222	222
Flight provisions	176	176	176	80	80	80
Passenger accommodations	2 025	4 000	5 400	918	1 814	2 449
Cargo handling						
Emergency equipment	135	135	135	61	61	61
Air conditioning	680	1 353	2 028	308	614	920
Anti-icing	60	60	60	27	27	27
Auxiliary power unit						
Miscellaneous accommodations	926	2 026	3 808	420	919	1 727
Total fixed equipment	7 378	12 606	17 924	3 347	5 718	8 130
Exterior paint	0	0	0	0	0	0
Options	0	0	0	0	0	0
Manufacturer's empty weight	22 217	40 084	58 528	10 078	18 182	26 548
Standard and operational items	520	520	520	236	236	236
Operational empty weight	22 737	40 604	59 048	10 313	18 418	26 784
Maximum zero fuel weight	32 737	60 204	89 048	14 850	27 308	40 392
Maximum taxi weight	35 650	66 000	97 000	16 171	29 938	44 000

TABLE 6-13.—WEIGHT STATEMENT—1985
TILT ROTOR VTOL
BASELINE AIRPLANES

Airplane Components	Passengers					
	50	100	150	50	100	150
	lb			kg		
Wing	2 111	4 105	6 211	957	1 862	2 817
Horizontal tail } Vertical tail	437	895	1 342	198	406	609
Body	3 374	6 323	8 839	1 530	2 868	4 009
Main landing gear } Nose landing gear	1 141	2 122	3 063	518	963	1 389
Nacelle and strut	549	918	1 272	249	416	577
Total structure	7 612	14 343	20 727	3 453	6 506	9 402
Engine	894	1 496	2 072	406	678	940
Engine accessories	318	532	737	144	241	334
Engine controls						
Starting system						
Fuel system	85	151	209	38	68	95
Propeller installation	2 168	4 264	6 358	983	1 934	2 884
Drive system	1 715	3 621	5 627	778	1 642	2 552
Total propulsion group	5 180	10 064	15 003	2 350	4 565	6 805
Instruments	210	210	210	95	95	95
Surface controls	2 683	4 893	7 033	1 217	2 219	3 190
Hydraulics	185	200	210	84	91	95
Pneumatics						
Electrical	545	615	650	247	279	295
Electronics	490	490	490	222	222	222
Flight provisions	175	175	175	79	79	79
Passenger accommodations	2 025	4 000	5 400	919	1 814	2 449
Cargo handling						
Emergency equipment	135	135	135	61	61	61
Air conditioning	520	907	1 420	236	411	644
Anti-icing	85	85	85	38	38	38
Auxiliary power unit						
Total fixed equipment	7 053	11 773	15 808	3 199	5 340	7 171
Exterior paint	0	0	0	0	0	0
Options	0	0	0	0	0	0
Manufacturer's empty weight	19 845	36 180	51 538	9 002	16 411	23 378
Standard and operational items	520	520	520	236	236	236
Operational empty weight	20 365	36 700	52 058	9 238	16 647	23 614
Maximum zero fuel weight	30 365	56 700	82 058	13 774	25 719	37 222
Maximum taxi weight	32 597	60 636	87 511	14 786	27 504	39 695

TABLE 6-14.—FIELD LENGTH SENSITIVITIES

Sensitivity	Airplane			
	1975		1985	
	lb/ft	kg/m	lb/ft	kg/m
$\frac{\partial W_{FUEL}}{\partial (FL)}$	-0.440	-0.654	-0.315	-0.468
$\frac{\partial W_{OEW}}{\partial (FL)}$	-3.00	-4.46	-1.60	-3.38
$\frac{\partial W_{GW}}{\partial (FL)}$	-4.10	-6.10	-2.30	-3.420

TABLE 6-15.–WEIGHT STATEMENT–1975 AUGMENTOR WING STOL, 95 PASSENGERS, FIELD LENGTH VARIATION

Airplane Components	Field length, ft					Field length, m				
	1,000	1,500	2,000	2,500	3,000	305	457	610	762	914
	lb					kg				
Wing	7 920	7 491	7 142	6 882	6 703	3 592	3 398	3 240	3 122	3 040
Horizontal tail	1 102	1 005	927	871	832	500	456	420	395	377
Vertical tail	657	599	559	529	508	298	272	254	240	230
Body	10 525	10 355	10 213	10 102	10 025	4 774	4 697	4 633	4 582	4 547
Main landing gear	1 198	1 171	1 148	1 131	1 119	543	531	521	513	508
Nose landing gear	262	257	252	249	247	119	117	114	113	112
Nacelle and strut										
Total structure	22 481	21 679	21 022	20 526	20 182	10 197	9 834	9 536	9 311	9 155
Engine	5 366	4 335	3 507	2 888	2 446	2 434	1 966	1 591	1 310	1 110
Engine accessories	254	237	220	206	195	115	108	100	93	88
Engine controls	75	75	75	75	75	34	34	34	34	34
Starting system	78	78	78	78	78	35	35	35	35	35
Fuel system	314	314	314	314	314	142	142	142	142	142
Thrust reverser	257	257	257	257	257	117	117	117	117	117
Air ducting system	682	668	655	646	639	309	303	297	293	290
Total propulsion group	7 026	5 964	5 107	4 464	4 004	3 187	2 705	2 317	2 025	1 816
Instruments	439	438	436	435	435	199	199	198	198	198
Surface controls	942	915	891	874	861	427	415	404	396	390
Hydraulics	358	352	348	344	342	162	160	158	156	155
Pneumatics	217	210	203	199	195	98	95	92	90	88
Electrical	1 087	1 087	1 087	1 087	1 087	493	493	493	493	493
Electronics	793	783	775	769	764	360	355	351	349	347
Flight provisions	501	501	501	501	501	227	227	227	227	227
Passenger accommodations	3 974	3 974	3 974	3 974	3 974	1 803	1 803	1 803	1 803	1 803
Cargo handling	179	179	179	179	179	81	81	81	81	81
Emergency equipment	126	122	118	116	114	57	55	54	53	52
Air conditioning	477	477	477	477	477	216	216	216	216	216
Anti-icing	127	121	116	112	109	58	55	53	51	49
Auxiliary power unit	0	0	0	0	0	0	0	0	0	0
Community noise abatement	883	714	575	472	397	400	324	261	214	180
Total fixed equipment	10 104	9 871	9 681	9 537	9 435	4 583	4 477	4 391	4 326	4 280
Exterior paint	0	0	0	0	0	0	0	0	0	0
Options	0	0	0	0	0	0	0	0	0	0
Manufacturer's empty weight	39 611	37 514	35 810	34 527	33 621	17 967	17 016	16 243	15 661	15 250
Standard and operational items	599	599	599	599	599	272	272	272	272	272
Operational empty weight	40 209	38 113	36 408	35 126	34 220	18 239	17 288	16 515	15 933	15 522
Maximum zero fuel weight	59 209	57 113	55 408	54 126	53 220	26 857	25 906	25 133	24 551	24 140
Maximum taxi weight	65 428	62 639	60 350	58 624	57 428	29 678	28 413	27 375	26 592	26 049
SLST per engine (2 engines)	18 058	14 595	11 768	9 644	8 126	8 191	6 620	5 338	4 375	3 686

TABLE 6-16.–WEIGHT STATEMENT–1985 AUGMENTOR WING STOL, 95 PASSENGERS, FIELD LENGTH VARIATION

Airplane Components	Field length, ft					Field length, m				
	1 000	1 500	2 000	2 500	3 000	305	457	610	762	914
Wing	2 713	2 599	2 514	2 442	2 387	1 231	1 179	1 140	1 108	1 083
Horizontal tail	517	478	449	425	407	234	217	204	193	185
Vertical tail	332	309	292	277	265	150	140	132	126	120
Body	7 077	6 990	6 922	6 864	6 818	3 210	3 171	3 140	3 114	3 093
Main landing gear	1 050	1 032	1 019	1 007	998	476	468	462	457	453
Nose landing gear	228	225	222	220	218	103	102	101	100	99
Nacelle and strut	955	938	924	911	900	433	425	419	413	408
Total structure	12 872	12 571	12 342	12 146	11 993	5 839	5 702	5 598	5 509	5 440
Engine	4 131	3 467	2 964	2 536	2 196	1 874	1 573	1 344	1 150	996
Engine accessories	242	228	216	206	196	110	103	98	93	89
Engine controls	72	72	72	72	72	33	33	33	33	33
Starting system	78	78	78	78	78	35	35	35	35	35
Fuel system	314	314	314	314	314	142	142	142	142	142
Thrust reverser	320	320	320	320	320	145	145	145	145	145
Air ducting system	502	494	488	482	478	228	224	221	219	217
Total propulsion group	5 660	4 974	4 452	4 008	3 655	2 567	2 256	2 019	1 818	1 658
Instruments	345	344	344	343	343	156	156	156	156	156
Surface controls	790	769	754	740	730	358	349	342	336	331
Hydraulics	247	245	243	241	240	112	111	110	109	109
Pneumatics	179	174	171	167	165	81	79	78	76	75
Electrical	761	761	761	761	761	345	345	345	345	345
Electronics	483	479	476	473	471	219	217	216	215	214
Flight provisions	401	401	401	401	401	182	182	182	182	182
Passenger accommodations	3 498	3 498	3 498	3 498	3 498	1 587	1 587	1 587	1 587	1 587
Cargo handling	179	179	179	179	179	81	81	81	81	81
Emergency equipment	104	102	99	98	96	47	46	45	44	44
Air conditioning	429	429	429	429	429	194	194	194	194	194
Anti-icing	107	103	100	97	95	49	47	45	44	43
Auxiliary power unit	0	0	0	0	0	0	0	0	0	0
Community noise abatement	765	641	546	466	401	347	291	248	211	182
Total fixed equipment	8 288	8 125	8 000	7 894	7 810	3 759	3 686	3 629	3 581	3 543
Exterior paint	0	0	0	0	0	0	0	0	0	0
Options	0	0	0	0	0	0	0	0	0	0
Manufacturer's empty weight	26 821	25 670	24 794	24 049	23 457	12 166	11 644	11 247	10 909	10 640
Standard and operational items	599	599	599	599	599	272	272	272	272	272
Operational empty weight	27 419	26 269	25 393	24 647	24 056	12 437	11 916	11 518	11 180	10 912
Maximum zero fuel weight	46 419	45 269	44 393	43 647	43 056	21 056	20 534	20 137	19 798	19 530
Maximum taxi weight	51 554	49 859	48 580	47 493	46 648	23 385	22 616	22 036	21 543	21 160
SLST per engine (2 engines)	15 647	13 113	11 173	9 522	8 210	7 097	5 948	5 068	4 319	3 724

TABLE 6-17.—THRUST LOADING SENSITIVITIES

Sensitivity[a]	Airplane			
	1975		1985	
	lb	kg	lb	kg
$\frac{\partial W_{FUEL}}{\partial (T/W)}$	3 000	1 360	2 500	1132
$\frac{\partial W_{OEW}}{\partial (T/W)}$	23 500	10 650	12 500	5600
$\frac{\partial W_{GW}}{\partial (T/W)}$	31 000	14 050	19 000	8610

[a]W_{FUEL} sensitivity refers to fuel burned.

TABLE 6-18.—WEIGHT STATEMENT—1975 AUGMENTOR WING STOL, 95 PASSENGERS, MACH NUMBER VARIATION

Airplane Components	Mach number							
	0.3	0.4	0.5	0.591	0.3	0.4	0.5	0.591
	lb				kg			
Wing	7 150	7 095	7 142	7 213	3 243	3 218	3 240	3 272
Horizontal tail	929	917	927	943	421	416	420	428
Vertical tail	560	554	559	567	254	251	254	257
Body	10 216	10 193	10 213	10 242	4 634	4 624	4 633	4 646
Main landing gear	1 148	1 147	1 148	1 150	521	520	521	522
Nose landing gear	252	252	252	253	114	114	114	114
Nacelle and strut	780	779	780	781	354	353	354	354
Total structure	21 036	20 937	21 022	21 148	9 542	9 497	9 536	9 593
Engine	3 510	3 489	3 507	3 533	1 592	1 583	1 591	1 603
Engine accessories	221	220	220	221	100	100	100	100
Engine controls	75	75	75	75	34	34	34	34
Starting system	78	78	78	78	35	35	35	35
Fuel system	314	314	314	314	142	142	142	142
Thrust reverser	257	257	257	257	117	117	117	117
Air ducting system	656	656	655	658	298	298	297	298
Total propulsion group	5 110	5 087	5 107	5 136	2 318	2 307	2 317	2 330
Instruments	436	436	436	437	198	198	198	198
Surface controls	892	888	891	896	405	403	404	406
Hydraulics	348	347	348	349	158	157	158	158
Pneumatics	203	202	203	205	92	92	92	93
Electrical	1 087	1 087	1 087	1 087	493	493	493	493
Electronics	775	774	775	777	352	351	352	352
Flight provisions	501	501	501	501	227	227	227	227
Passenger accommodations	3 974	3 974	3 974	3 974	1 803	1 803	1 803	1 803
Cargo handling	179	179	179	179	81	81	81	81
Emergency equipment	118	118	118	119	54	54	54	54
Air conditioning	477	477	477	477	216	216	216	216
Anti-icing	116	116	116	116	53	53	53	53
Auxiliary power unit	0	0	0	0	0	0	0	0
Community noise abatement	576	573	575	580	261	260	261	263
Total fixed equipment	9 682	9 671	9 681	9 695	4 392	4 387	4 391	4 398
Exterior paint	0	0	0	0	0	0	0	0
Options	0	0	0	0	0	0	0	0
Manufacturer's empty weight	35 828	35 695	35 810	35 979	16 252	16 191	26 243	16 320
Standard and operational items	599	599	599	599	272	272	272	272
Operational empty weight	36 427	36 294	36 409	36 577	16 523	16 463	16 515	16 591
Maximum zero fuel weight	55 427	55 294	55 409	55 577	25 142	25 081	25 133	25 210
Maximum taxi weight	60 403	60 039	60 350	60 812	27 399	27 234	27 375	27 584

TABLE 6-19.—WEIGHT STATEMENT—1985 AUGMENTOR WING STOL, 95 PASSENGERS, MACH NUMBER VARIATION

Airplane Components	Mach number							
	0.3	0.4	0.5	0.6	0.3	0.4	0.5	0.6
	lb				kg			
Wing	2 536	2 506	2 514	2 532	1 150	1 137	1 140	1 149
Horizontal tail	457	447	449	455	207	203	204	206
Vertical tail	296	290	292	296	134	132	132	134
Body	6 940	6 916	6 922	6 937	3 148	3 137	3 140	3 147
Main landing gear	1 020	1 018	1 019	1 020	463	462	462	463
Nose landing gear	223	222	222	223	101	101	101	101
Nacelle and strut	924	923	924	924	419	419	419	419
Total structure	12 396	12 322	12 342	12 387	5 623	5 589	5 598	5 619
Engine	2 984	2 957	2 964	2 980	1 354	1 341	1 344	1 352
Engine accessories	217	217	217	217	98	98	98	98
Engine controls	72	72	72	72	33	33	33	33
Starting system	78	78	78	78	35	35	35	35
Fuel system	314	314	314	314	142	142	142	142
Thrust reverser	320	320	320	320	145	145	145	145
Air ducting system	489	487	488	489	222	221	221	222
Total propulsion group	4 485	4 445	4 452	4 471	2 034	2 016	2 019	2 028
Instruments	344	344	344	344	156	156	156	156
Surface controls	758	752	754	757	344	341	342	343
Hydraulics	243	243	243	243	110	110	110	110
Pneumatics	171	170	171	171	78	77	78	78
Electrical	761	761	761	761	345	345	345	345
Electronics	477	476	476	477	216	216	216	216
Flight provisions	401	401	401	401	182	182	182	182
Passenger accommodations	3 498	3 498	3 498	3 498	1 587	1 587	1 587	1 587
Cargo handling	179	179	179	179	81	81	81	81
Emergency equipment	100	99	99	100	45	45	45	45
Air conditioning	429	429	429	429	194	194	194	194
Anti-icing	100	100	100	100	45	45	45	45
Auxiliary power unit	0	0	0	0	0	0	0	0
Community noise abatement	550	545	546	550	249	248	248	249
Total fixed equipment	8 011	7 997	8 000	8 010	3 634	3 627	3 629	3 633
Exterior paint	0	0	0	0	0	0	0	0
Options	0	0	0	0	0	0	0	0
Manufacturer's empty weight	24 883	24 764	24 794	24 867	11 287	11 233	11 247	11 280
Standard and operational items	599	599	599	599	272	272	272	272
Operational empty weight	25 481	25 362	25 393	25 466	11 558	11 504	11 518	11 551
Maximum zero fuel weight	44 481	44 362	44 393	44 466	20 176	20 123	20 137	20 170
Maximum taxi weight	48 918	48 462	48 580	48 860	22 189	21 982	22 036	22 163

TABLE 6-20.—WEIGHT STATEMENT—1985 TILT ROTOR VTOL, 100 PASSENGERS, DISC LOADING VARIATION

Airplane components	Rotor loading					
	lb/sq ft			kg/sq m		
	11	15	19	53.7	73.3	92.8
	lb			kg		
Wing	4,500	4 105	3 775	2 041	1 862	1 712
Horizontal tail } Vertical tail	816	875	924	370	397	419
Body	6 200	6 323	6 390	2 812	2 868	2 898
Main landing gear } Nose landing gear	2 050	2 122	2 180	930	963	989
Nacelle and strut	750	918	1 068	340	416	484
Total structure	14 316	14 343	14 337	6 494	6 506	6 503
Engine	1 213	1 496	1 725	550	679	782
Engine accessories	435	532	616	197	241	279
Engine controls						
Starting system						
Fuel system	126	151	172	57	68	78
Propeller installation	3 860	4 264	4 580	1 751	1 934	2 077
Drive system	3 300	3 621	3 840	1 497	1 642	1 742
Total propulsion group	8 934	10 064	10 933	4 052	4 565	4 959
Instruments	210	210	210	95	95	95
Surface controls	4 600	4 893	5 080	2 086	2 219	2 304
Hydraulics	180	200	220	82	91	100
Pneumatics						
Electrical	615	615	615	279	279	279
Electronics	490	490	490	222	222	222
Flight provisions	175	175	175	79	79	79
Passenger accommodations	4 000	4 000	4 000	1 814	1 814	1 814
Cargo handling						
Emergency equipment	135	135	135	61	61	61
Air conditioning	970	970	970	440	440	440
Anti-icing	85	85	85	39	39	39
Auxiliary power unit						
Total fixed equipment	11 460	11 773	11 980	5 198	5 340	5 434
Exterior paint	0	0	0	0	0	0
Options	0	0	0	0	0	0
Manufacturer's empty weight	34 710	36 180	37 250	15 744	16 411	16 897
Standard and operational items	520	520	520	236	236	236
Operational empty weight	35 230	36 700	37 770	15 980	16 647	17 132
Maximum zero fuel weight	55 230	56 700	57 770	25 052	25 719	26 204
Maximum taxi weight	58 500	60 636	62 300	26 536	27 504	28 259

TABLE 6-21.—WEIGHT STATEMENT—1975 AUGMENTOR WING STOL, TYPE II INTERIOR

Airplane components	Passengers					
	53	109	155	53	109	155
	lb			kg		
Wing	4 450	8 265	10 983	2 019	3 749	4 982
Horizontal tail	721	1 182	1 126	327	536	511
Vertical tail	435	685	659	197	311	299
Body	6 754	10 839	13 099	3 064	4 917	5 942
Main landing gear	746	1 224	1 742	338	555	790
Nose landing gear	217	266	494	98	121	224
Nacelle and strut	419	791	1 633	190	359	741
Total structure	13 743	23 251	29 737	6 234	10 547	13 489
Engine	1 967	3 922	6 052	892	1 779	2 745
Engine accessories	191	229	252	87	104	114
Engine controls	65	75	85	29	34	39
Starting system	78	78	78	35	35	35
Fuel system	214	314	410	97	142	186
Thrust reverser	130	257	384	59	117	174
Air ducting system	529	694	801	240	315	363
Total propulsion group	3 174	5 569	8 063	1 440	2 526	3 657
Instruments	425	440	453	193	200	205
Surface controls	654	964	1 166	297	437	529
Hydraulics	304	363	407	138	165	185
Pneumatics	144	223	283	65	101	128
Electrical	1 087	1 087	1 087	493	493	493
Electronics	699	801	883	317	363	401
Flight provisions	468	501	544	212	227	247
Passenger accommodations	2 982	4 668	6 299	1 353	2 117	2 857
Cargo handling	115	225	304	52	102	138
Emergency equipment	85	130	166	39	59	75
Air conditioning	507	606	733	230	275	332
Anti-icing	108	118	126	49	54	57
Auxiliary power unit	0	0	0	0	0	0
Community noise abatement	375	645	860	170	293	390
Total fixed equipment	7 955	10 771	13 310	3 608	4 886	6 037
Exterior paint	0	0	0	0	0	0
Options	0	0	0	0	0	0
Manufacturer's empty weight	24 872	39 591	51 109	11 282	17 958	23 183
Standard and operational items	535	686	724	243	311	328
Operational empty weight	25 407	40 277	51 833	11 525	18 270	23 511
Maximum zero fuel weight	36 007	62 077	82 833	16 333	28 158	37 573
Maximum taxi weight	39 375	67 639	90 150	17 861	30 681	40 892

TABLE 6-22.—WEIGHT STATEMENT—1985 AUGMENTOR WING STOL, TYPE II INTERIOR

Airplane components	Passengers					
	53	109	155	53	109	155
	lb			kg		
Wing	1 701	2 912	3 775	771	1 321	1 712
Horizontal tail	371	587	554	168	266	251
Vertical tail	247	373	343	112	169	156
Body	4 797	7 348	8 755	2 176	3 333	3 971
Main landing gear	665	1 087	1 550	302	493	703
Nose landing gear	192	234	436	87	106	198
Nacelle and strut	510	934	1 766	231	424	801
Total structure	8 483	13 474	17 178	3 848	6 112	7 792
Engine	1 798	3 317	4 631	816	1 505	2 101
Engine accessories	189	225	248	86	102	112
Engine controls	63	72	81	29	33	37
Starting system	78	78	78	35	35	35
Fuel system	214	314	410	97	142	186
Thrust reverser	161	320	479	73	145	217
Air ducting system	395	516	597	179	234	271
Total propulsion group	2 897	4 843	6 525	1 314	2 197	2 960
Instruments	337	346	355	153	157	161
Surface controls	525	825	1 024	238	374	464
Hydraulics	216	252	280	98	114	127
Pneumatics	123	187	237	56	85	108
Electrical	761	761	761	345	345	345
Electronics	437	490	533	198	222	242
Flight provisions	375	401	435	170	182	197
Passenger accommodations	2 627	4 108	5 545	1 192	1 863	2 515
Cargo handling	115	225	304	52	102	138
Emergency equipment	73	109	138	33	49	63
Air conditioning	453	546	660	21	25	30
Anti-icing	97	102	112	44	46	51
Auxiliary power unit	0	0	0	0	0	0
Community noise abatement	358	613	820	162	278	372
Total fixed equipment	6 497	8 964	11 205	2 947	4 066	5 083
Exterior paint	0	0	0	0	0	0
Options	0	0	0	0	0	0
Manufacturer's empty weight	17 877	27 281	34 908	8 109	12 375	15 834
Standard and operational items	535	686	724	243	311	328
Operational empty weight	18 412	27 967	35 632	8 352	12 686	16 163
Maximum zero fuel weight	29 012	49 767	66 632	13 160	22 574	30 224
Maximum taxi weight	31 873	54 497	72 904	14 457	24 720	33 069

TABLE 6-23.–WEIGHT STATEMENT–1975 AUGMENTOR WING STOL, TYPE III INTERIOR

Airplane components	Passengers					
	52	101	150	52	101	150
	lb			kg		
Wing	4 615	8 061	10 438	2 093	3 656	4 735
Horizontal tail	772	1 134	1 046	350	514	474
Vertical tail	465	663	615	211	301	279
Body	7 460	11 647	12 267	3 384	5 283	5 564
Main landing gear	758	1 210	1 704	344	549	773
Nose landing gear	220	264	484	100	120	220
Nacelle and strut	420	789	1 627	191	358	738
Total structure	14 710	23 769	28 181	6 672	10 782	12 783
Engine	2 022	3 848	5 814	917	1 745	2 637
Engine accessories	193	227	248	88	103	112
Engine controls	65	75	85	29	34	39
Starting system	78	78	78	35	35	35
Fuel system	214	314	410	97	142	186
Thrust reverser	130	257	384	59	116	174
Air ducting system	537	687	785	243	312	356
Total propulsion group	3 238	5 486	7 806	1 469	2 488	3 541
Instruments	426	440	451	193	200	206
Surface controls	668	951	1 136	303	431	515
Hydraulics	307	360	400	139	163	181
Pneumatics	148	220	274	67	100	124
Electrical	1 087	1 087	1 087	493	493	493
Electronics	703	797	870	319	361	395
Flight provisions	468	501	576	212	227	261
Passenger accommodations	3 073	4 648	6 060	1 394	2 108	2 749
Cargo handling	126	235	287	57	106	130
Emergency equipment	87	128	160	39	58	73
Air conditioning	580	641	691	263	291	313
Anti-icing	109	118	125	49	54	57
Auxiliary power unit	0	0	0	0	0	0
Community noise abatement	386	633	826	175	287	375
Total fixed equipment	8 168	10 757	12 944	3 705	4 879	5 871
Exterior paint	0	0	0	0	0	0
Options	0	0	0	0	0	0
Manufacturer's empty weight	26 117	40 012	48 931	11 047	18 149	22 195
Standard and operational items	531	619	710	241	281	322
Operational empty weight	26 647	40 631	49 641	12 087	18 430	22 517
Maximum zero fuel weight	37 047	60 831	79 641	16 804	27 593	36 125
Maximum taxi weight	40 515	66 335	86 638	18 378	30 089	39 299

TABLE 6-24.—WEIGHT STATEMENT—1985
AUGMENTOR WING STOL,
TYPE III INTERIOR

Airplane components	Passengers					
	52	101	150	52	101	150
	lb			kg		
Wing	1 749	2 807	3 605	793	1 273	1 635
Horizontal tail	393	549	511	178	249	232
Vertical tail	263	351	319	119	159	145
Body	5 294	7 873	8 214	2 401	3 571	3 726
Main landing gear	672	1 069	1 519	305	485	689
Nose landing gear	193	231	428	88	105	194
Nacelle and strut	511	931	1 761	232	422	799
Total structure	9 076	13 811	16 357	4 117	6 265	7 420
Engine	1 835	3 224	4 467	832	1 462	2 026
Engine accessories	190	223	245	86	101	111
Engine controls	63	72	81	29	33	37
Starting system	78	78	78	35	35	35
Fuel system	214	314	410	97	142	186
Thrust reverser	161	320	479	73	145	217
Air ducting system	399	509	587	181	231	266
Total propulsion group	2 941	4 741	6 347	1 334	2 150	2 879
Instruments	337	346	353	153	157	160
Surface controls	536	807	998	243	366	453
Hydraulics	218	250	276	99	113	125
Pneumatics	125	183	230	57	83	104
Electrical	761	761	761	345	345	345
Electronics	438	486	527	199	220	239
Flight provisions	375	401	461	170	182	209
Passenger accommodations	2 707	4 088	5 342	1 228	1 854	2 423
Cargo handling	126	235	287	57	106	130
Emergency equipment	74	106	134	34	48	61
Air conditioning	518	578	623	235	262	283
Anti-icing	97	101	111	44	46	50
Auxiliary power unit	0	0	0	0	0	0
Community noise abatement	366	595	791	166	270	359
Total fixed equipment	6 678	8 936	10 895	3 029	4 053	4 942
Exterior paint	0	0	0	0	0	0
Options	0	0	0	0	0	0
Manufacturer's empty weight	18 695	27 433	33 599	8 480	12 444	15 241
Standard and operational items	531	619	710	241	281	322
Operational empty weight	19 226	28 107	34 309	8 721	12 749	15 563
Maximum zero fuel weight	29 626	48 307	64 309	13 438	21 912	29 170
Maximum taxi weight	32 566	52 947	70 325	14 772	24 017	31 899

TABLE 6-25.—WEIGHT STATEMENT—1975 AUGMENTOR WING STOL, LOW MAINTENANCE ENGINE SENSITIVITY

Airplane components	Baseline airplane	Low-maintenance engine airplane	Baseline airplane	Low-maintenance engine airplane
	lb		kg	
Wing	4 126	4 280	1 871	1 941
Horizontal tail	625	671	284	304
Vertical tail	377	405	171	184
Body	6 678	6 749	3 029	3 061
Main landing gear	722	732	327	332
Nose landing gear	211	214	96	97
Nacelle and strut	418	418	190	190
Total structure	13 156	13 469	5 968	6 110
Engine	1 857	2 197	842	997
Engine accessories	188	190	85	86
Engine controls	65	65	29	29
Starting system	78	78	35	35
Fuel system	214	214	97	97
Thrust reverser	130	130	59	59
Air ducting system	514	521	233	236
Total propulsion group	3 046	3 394	1 382	1 540
Instruments	424	424	192	192
Surface controls	625	639	283	290
Hydraulics	300	302	136	137
Pneumatics	138	141	63	64
Electrical	1 087	1 087	493	493
Electronics	691	695	313	315
Flight provisions	468	468	212	212
Passenger accommodations	2 706	2 706	1 227	1 227
Cargo handling	95	95	43	43
Emergency equipment	81	83	37	38
Air conditioning	364	364	165	165
Anti-icing	108	108	49	49
Auxiliary power unit	0	0	0	0
Community noise abatement	354	364	161	165
Total fixed equipment	7 441	7 477	3 375	3 392
Exterior paint	0	0	0	0
Options	0	0	0	0
Manufacturer's empty weight	23 643	24 340	10 724	11 041
Standard and operational items	517	517	235	235
Operational empty weight	24 160	24 857	10 959	11 275
Maximum zero fuel weight	33 960	34 657	15 404	15 270
Maximum taxi weight	37 118	38 194	16 837	17 325
SLST per engine (2 engines)	7 238	7 448	3 283	3 378

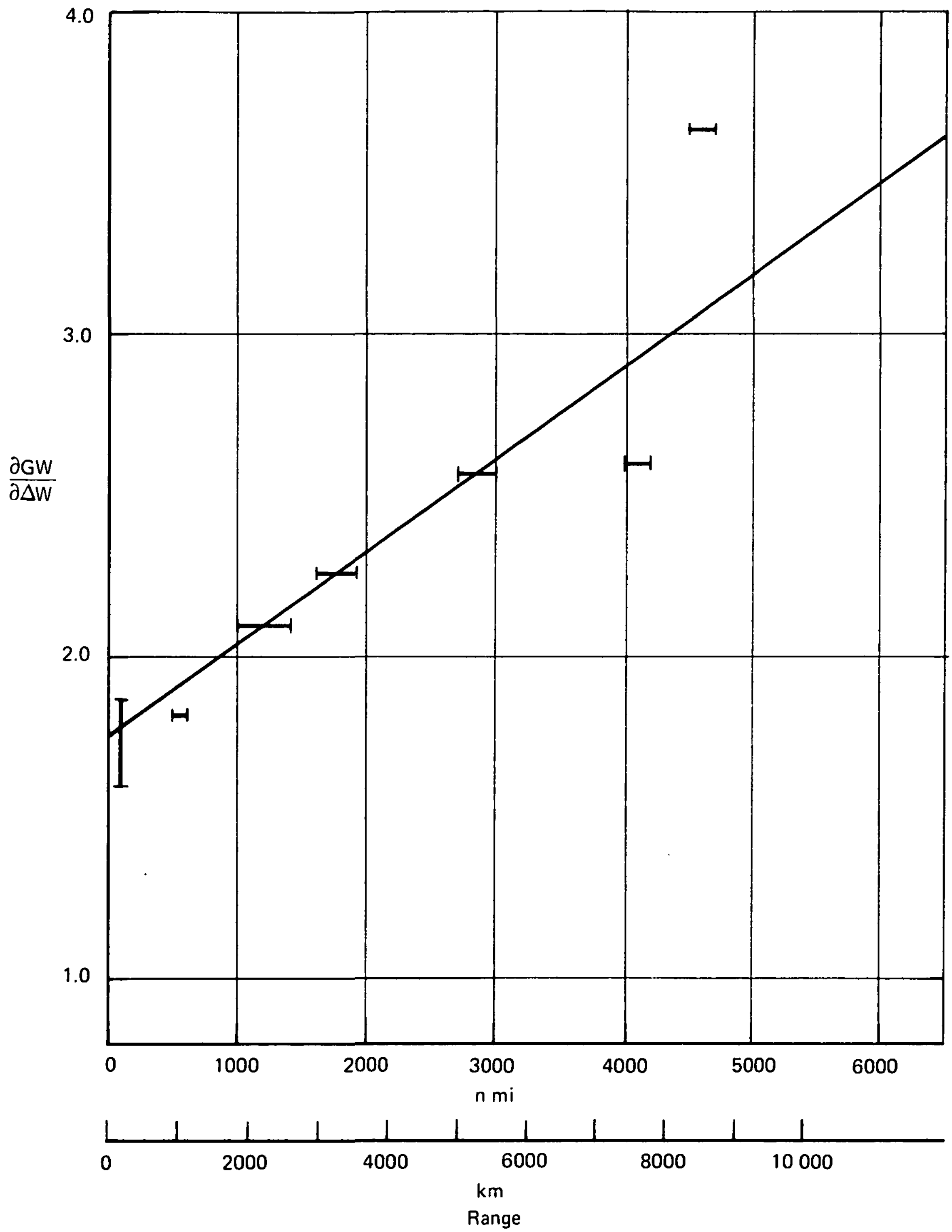


FIGURE 6-1.—APPROXIMATE GROSS WEIGHT SENSITIVITY TO SMALL COMPONENT WEIGHT CHANGES

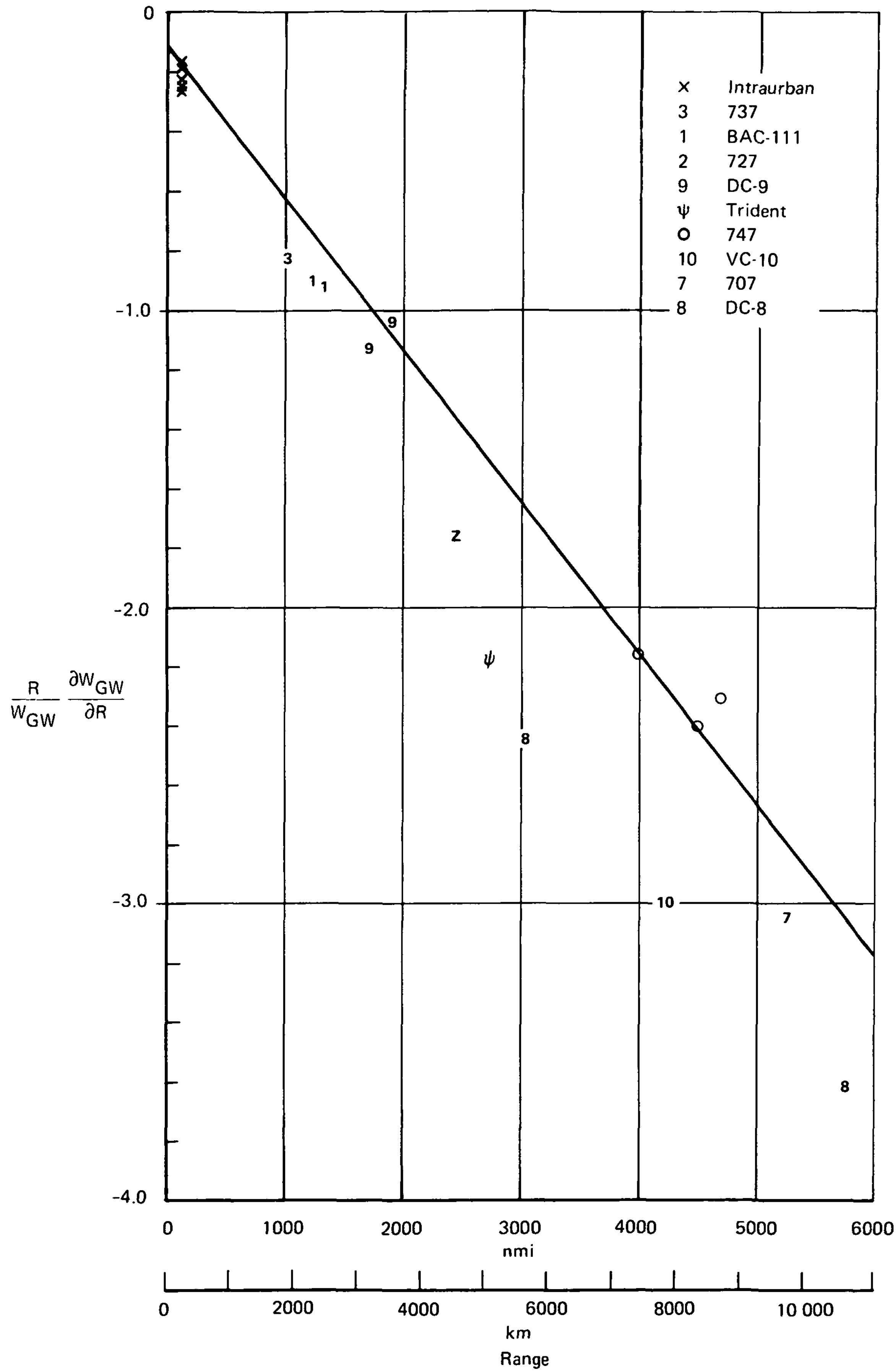
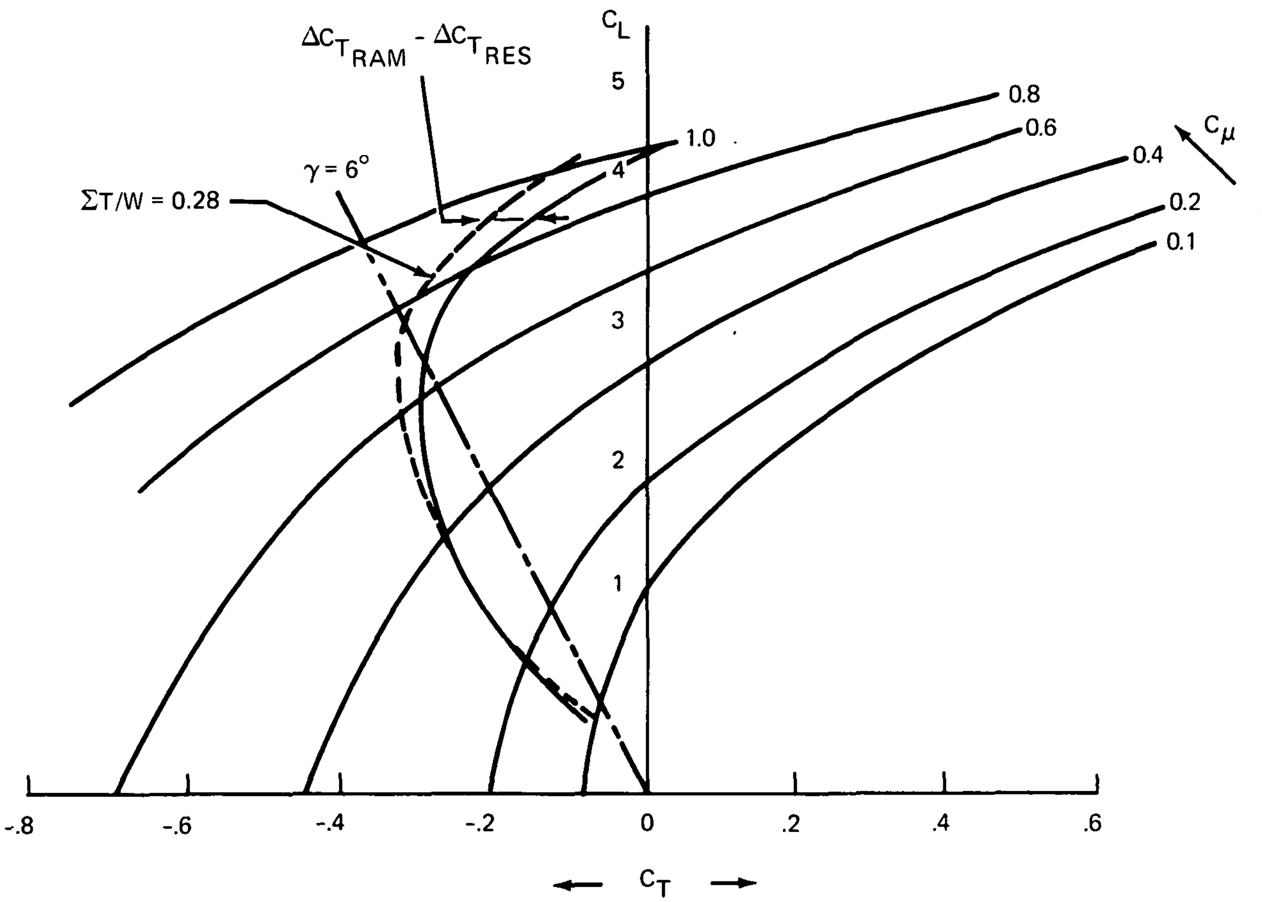


FIGURE 6-2.—GROSS WEIGHT SENSITIVITY TO MISSION RANGE FACTOR

$$C_r = C_{D_o} + \frac{K\,C_L^{\;2}}{\pi\,AR + 1.2(2\,C_\mu)} - 1.2(R \cdot C_\mu)_{AUG.} - \Delta C_{T_{RESIDUAL}} + \Delta C_{T_{RAM_{ENGINE}}}$$



Assumptions: $R = 0.9$

$C_\mu = (T/W)_{AUG\ PRIMARY} \times C_L$

Augmentation = 20% (assumed constant)

$C_L = W/qs$

$C_{D_o} = 0.0360$ takeoff flap

FIGURE 6-3.—LOW-SPEED PERFORMANCE—AUGMENTOR WING TAKEOFF FLAP

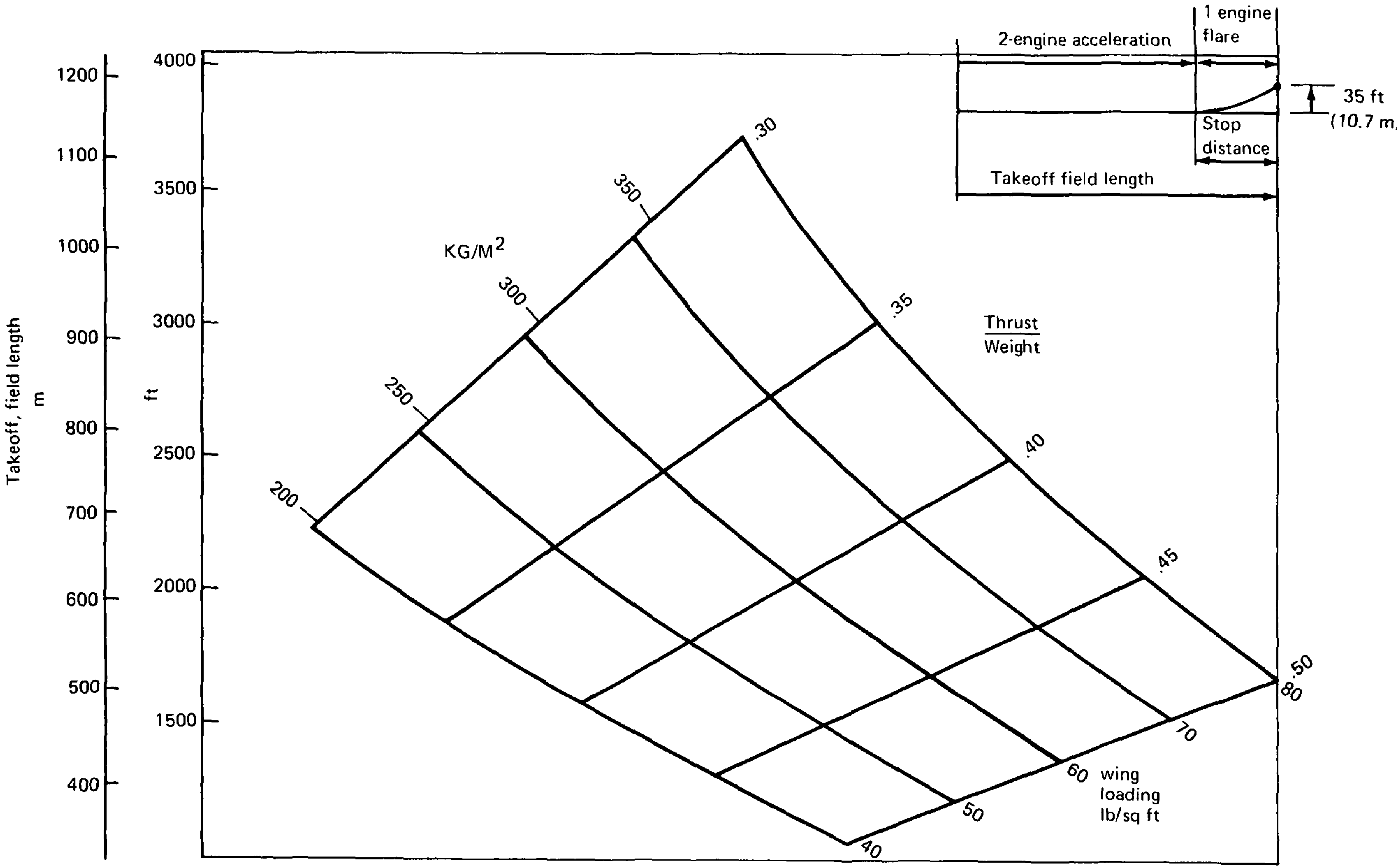


FIGURE 6-4.—TAKEOFF FIELD LENGTH—TWIN-ENGINE AUGMENTOR WING STOL

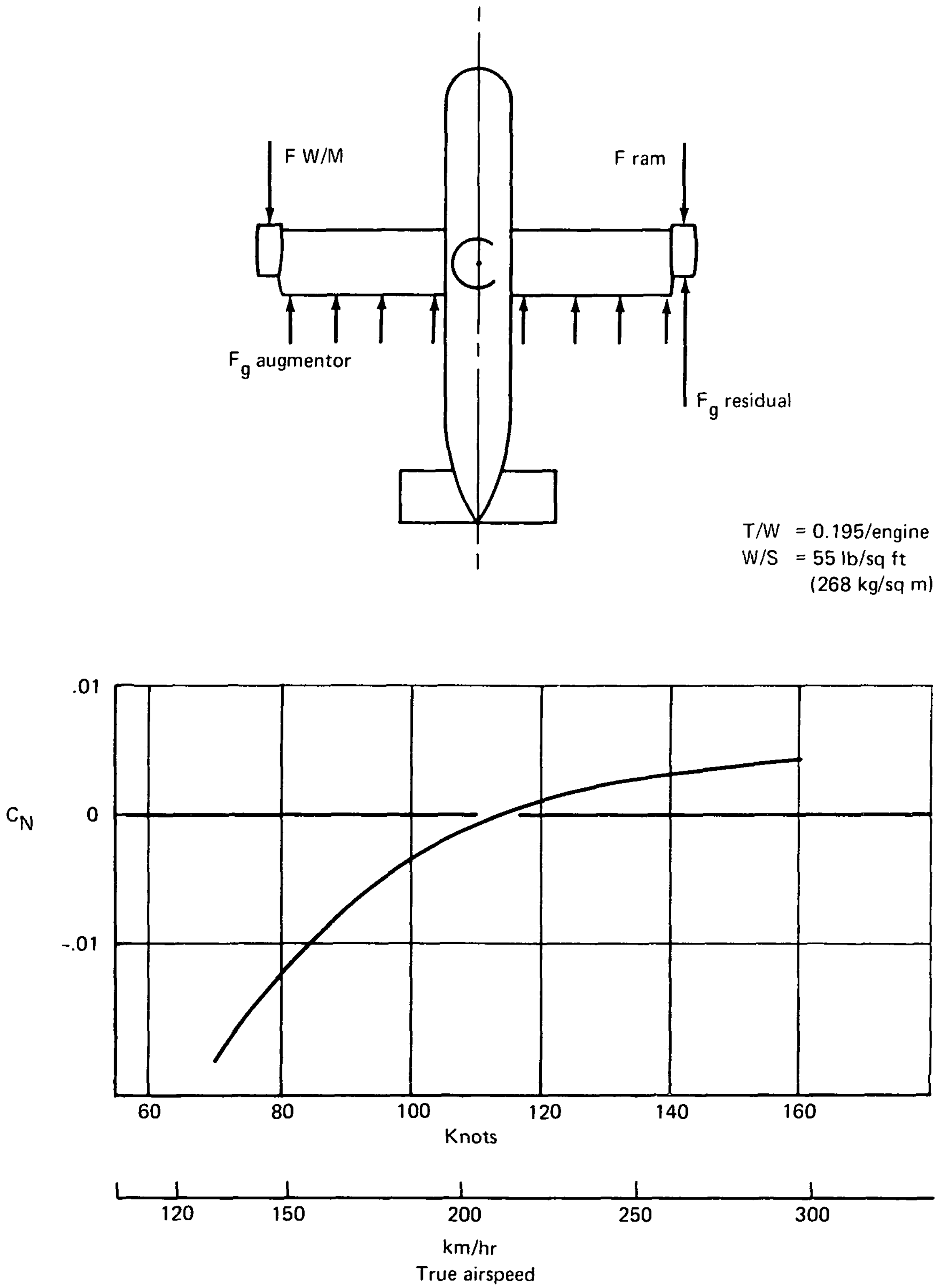


FIGURE 6-5.- YAWING MOMENT COEFFICIENT–WINDMILLING ENGINE

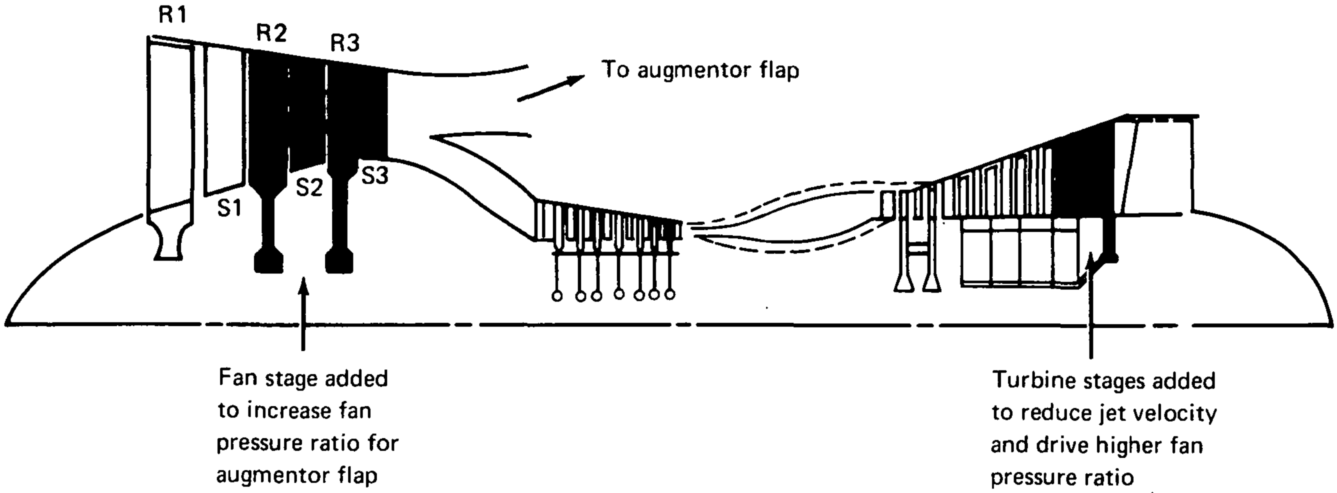


FIGURE 6-6.--BOEING CONCEPT OF AUGMENTOR WING PRIMARY ENGINE

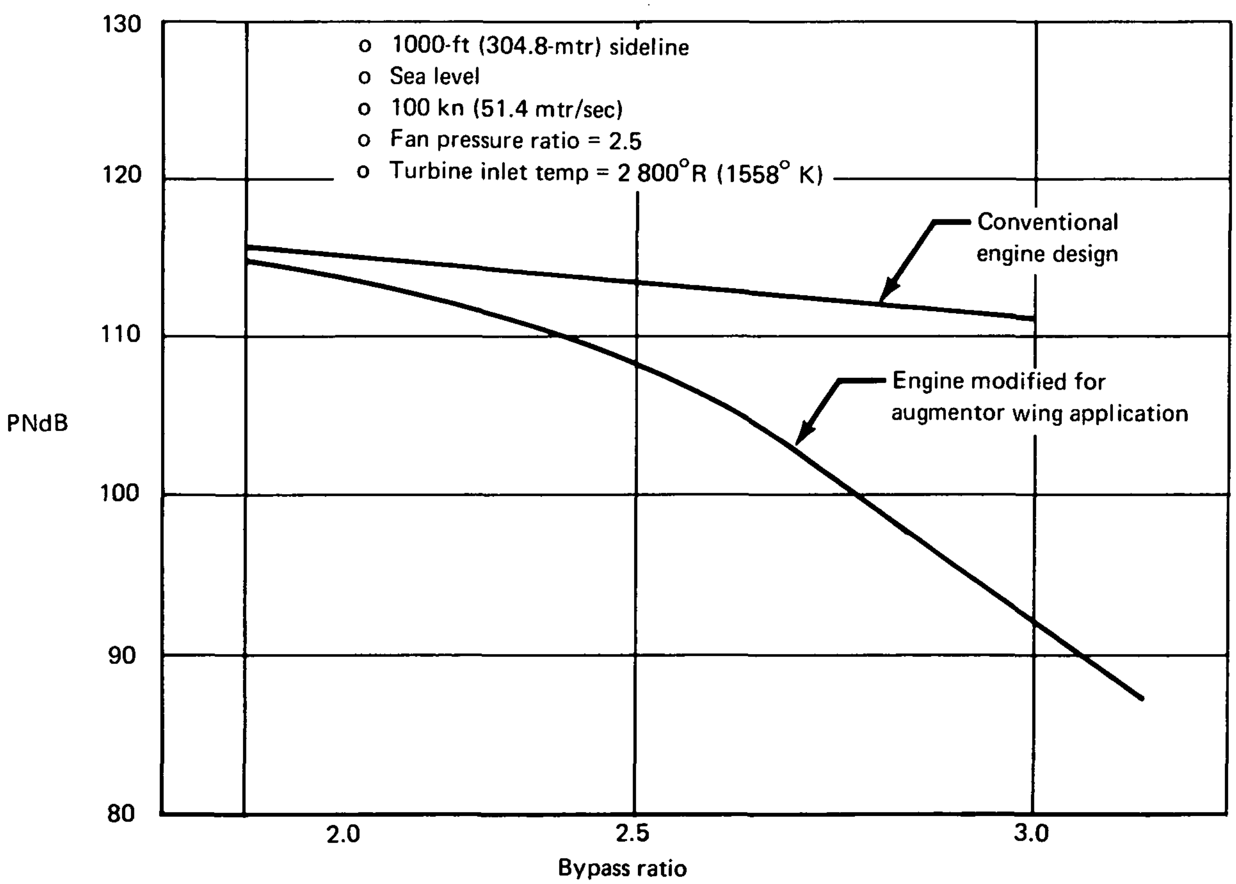


FIGURE 6-7.–AUGMENTOR WING ENGINE JET NOISE PERFORMANCE COMPARISON

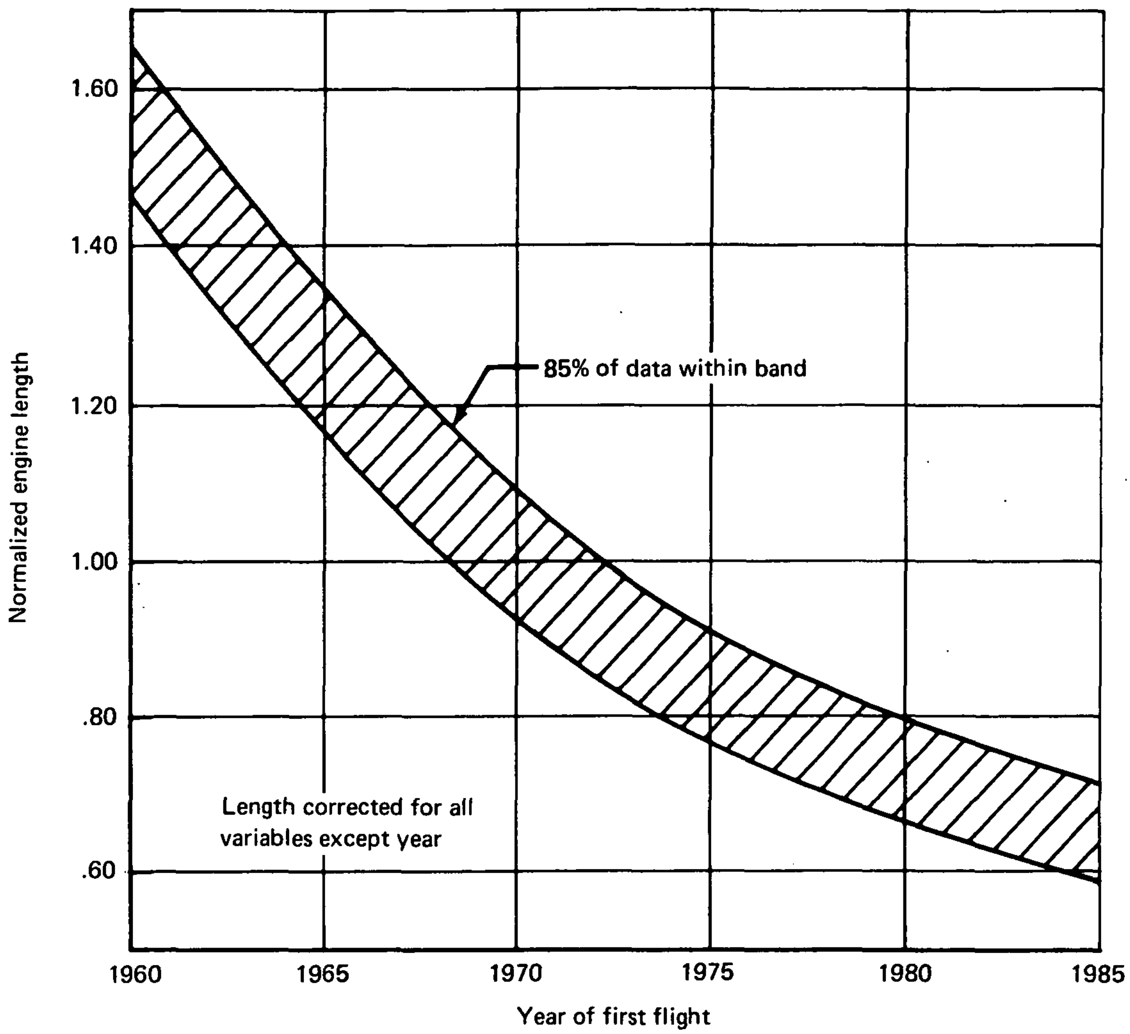


FIGURE 6-8.—TREND IN ENGINE LENGTH

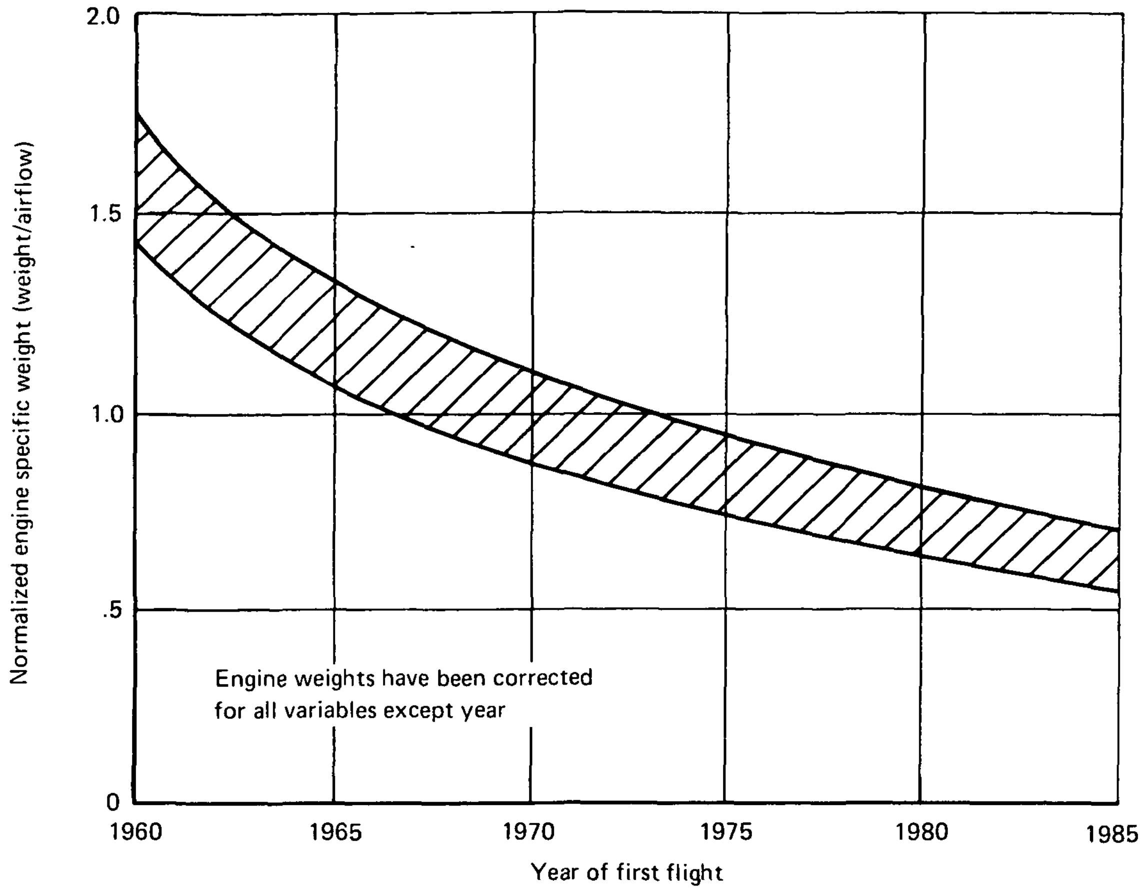


FIGURE 6-9.--TREND IN ENGINE WEIGHT

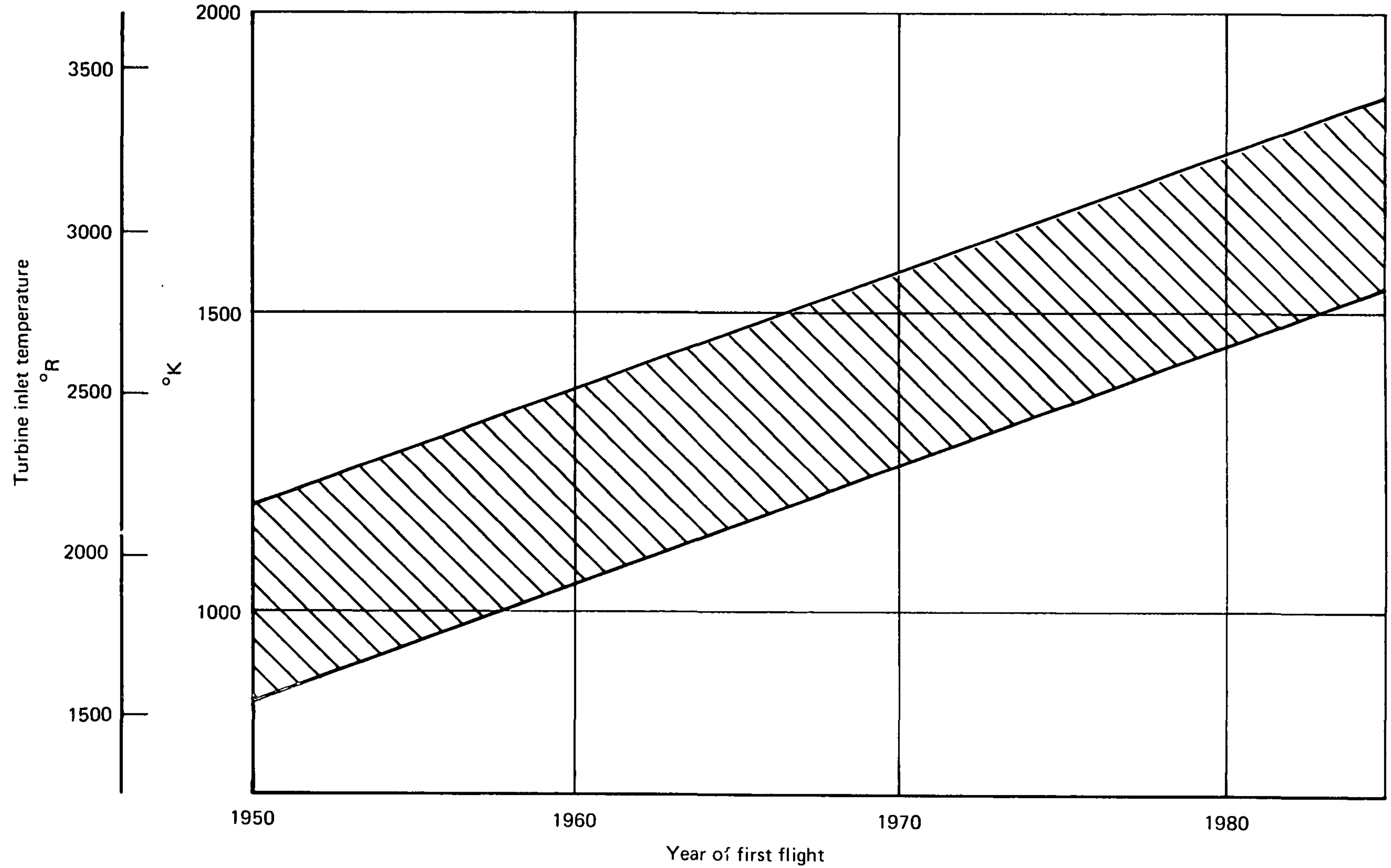


FIGURE 6-10.—TREND IN TURBINE INLET TEMPERATURE

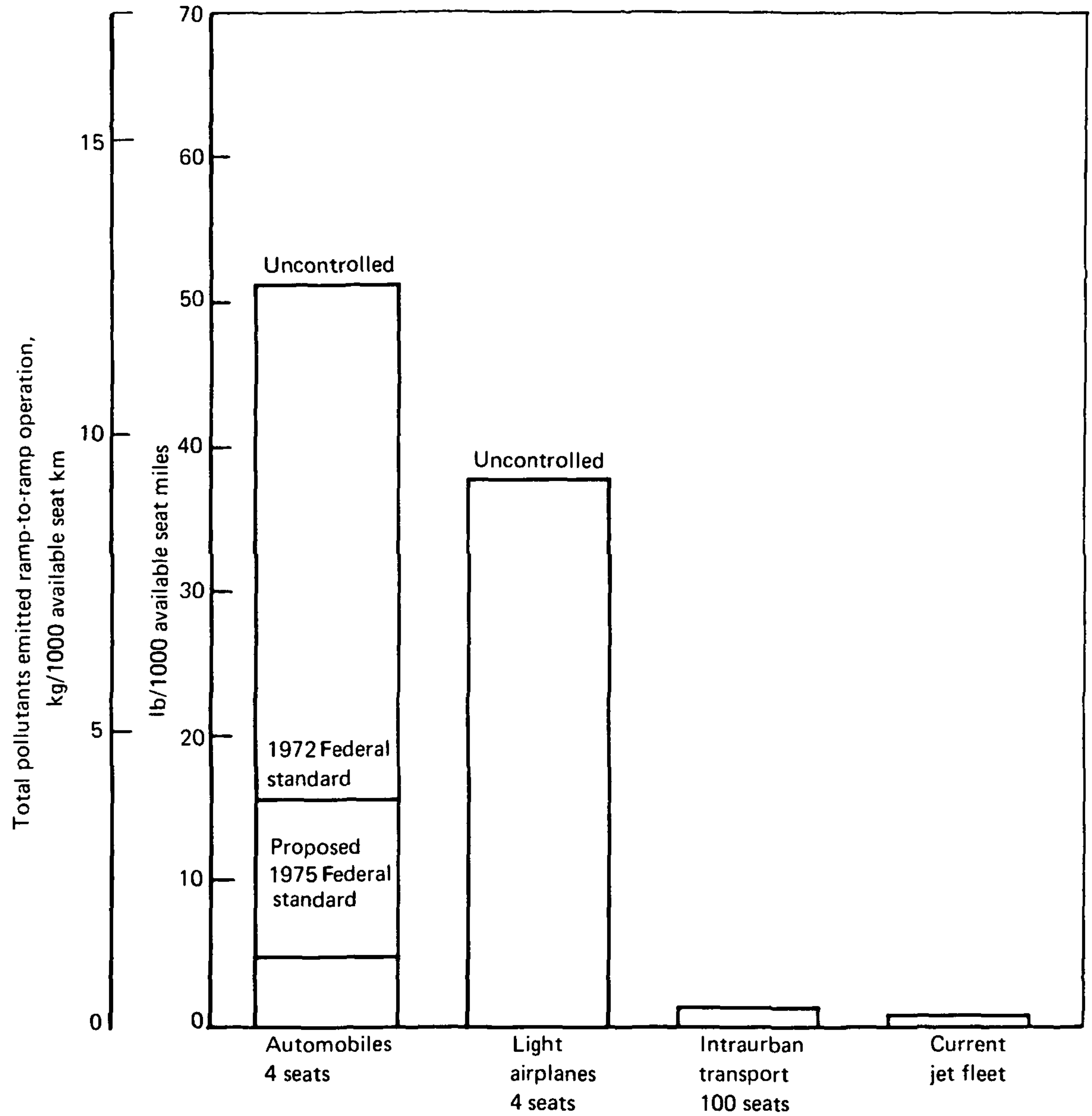


FIGURE 6-11.—POLLUTION CHARACTERISTICS

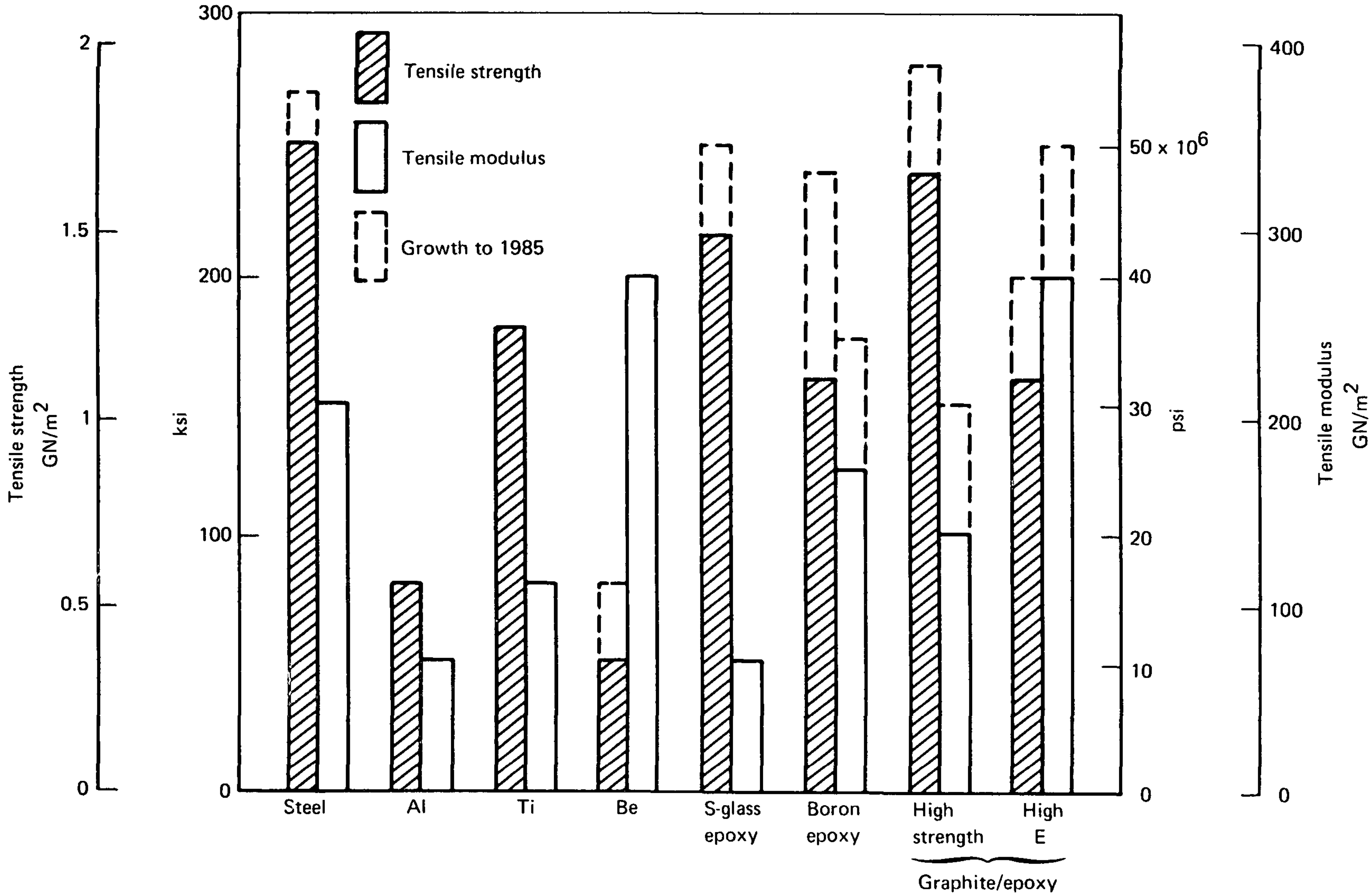


FIGURE 6-12.—TENSILE STRENGTH AND MODULUS OF STRUCTURAL MATERIALS

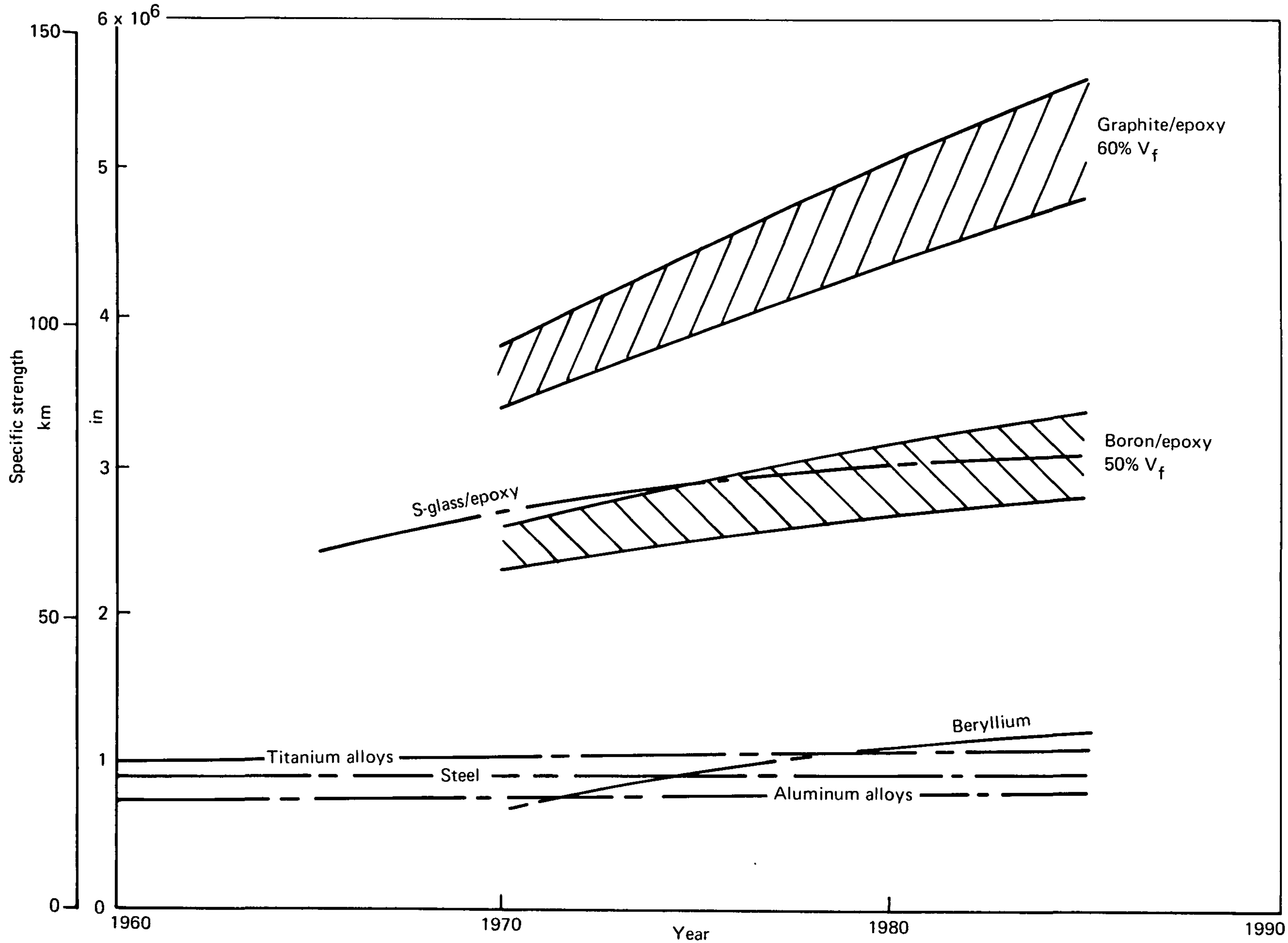


FIGURE 6-13. SPECIFIC STRENGTH COMPARISON OF STRUCTURAL MATERIALS

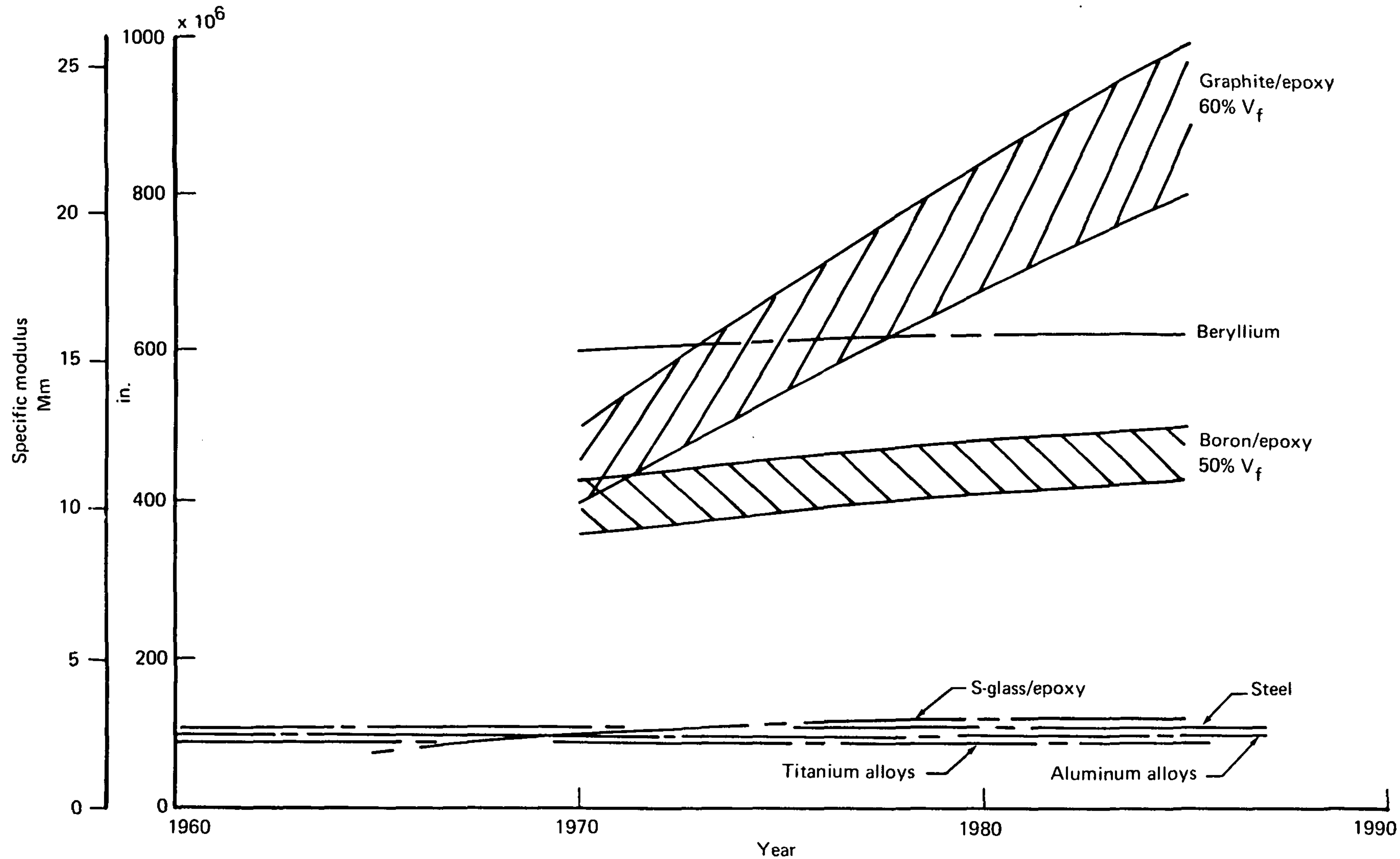


FIGURE 6-14.—SPECIFIC MODULUS COMPARISON OF STRUCTURAL MATERIALS

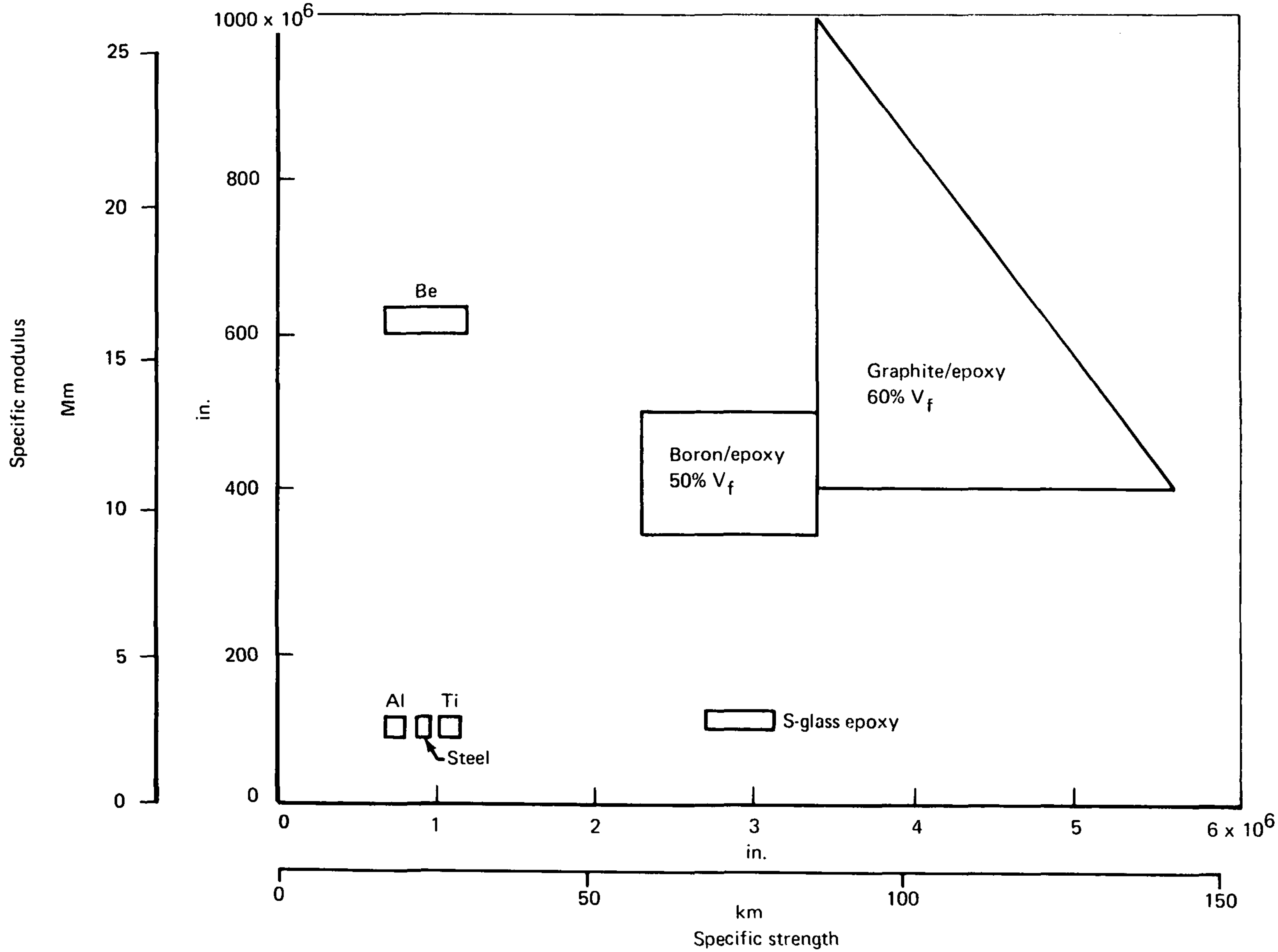
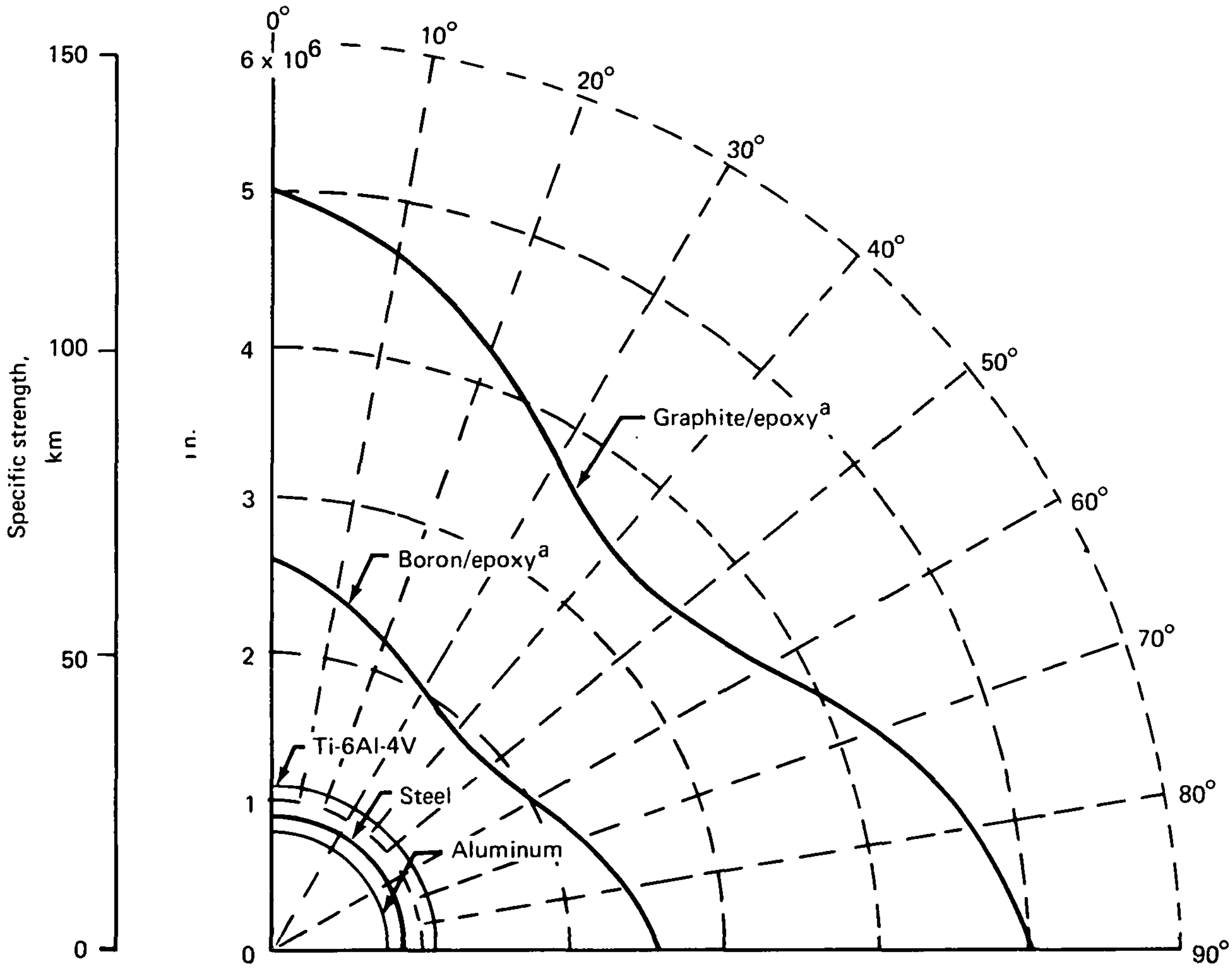
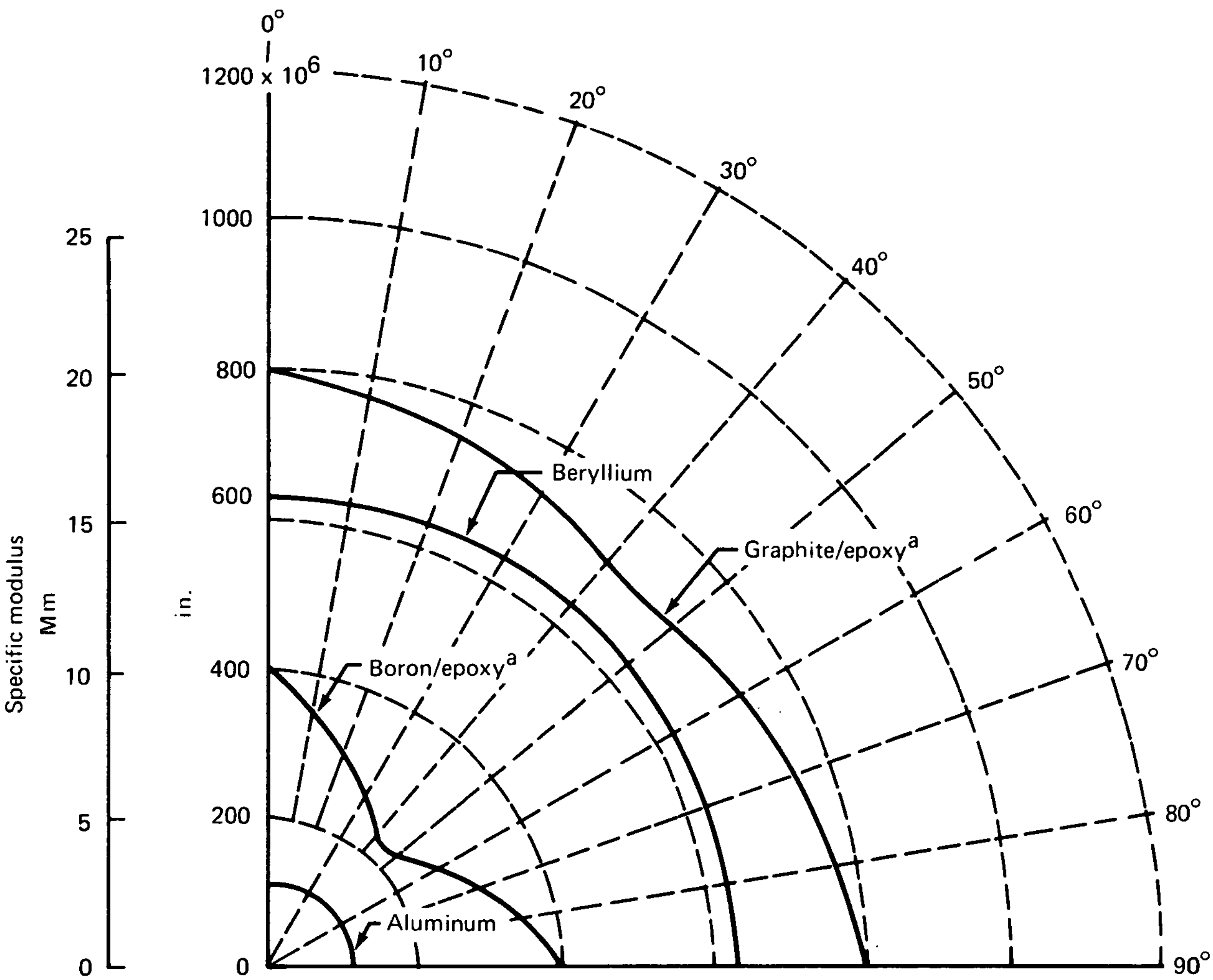


FIGURE 6-15.—SPECIFIC STRENGTH AND MODULUS OF STRUCTURAL MATERIALS



a. 1985 projections, based on 90°-oriented filaments

FIGURE 6-16.—SPECIFIC STRENGTH ANISOTROPIC CURVES



a. 1985 projections, based on 90°-oriented filaments

FIGURE 6-17.–SPECIFIC MODULUS ANISOTROPIC CURVES

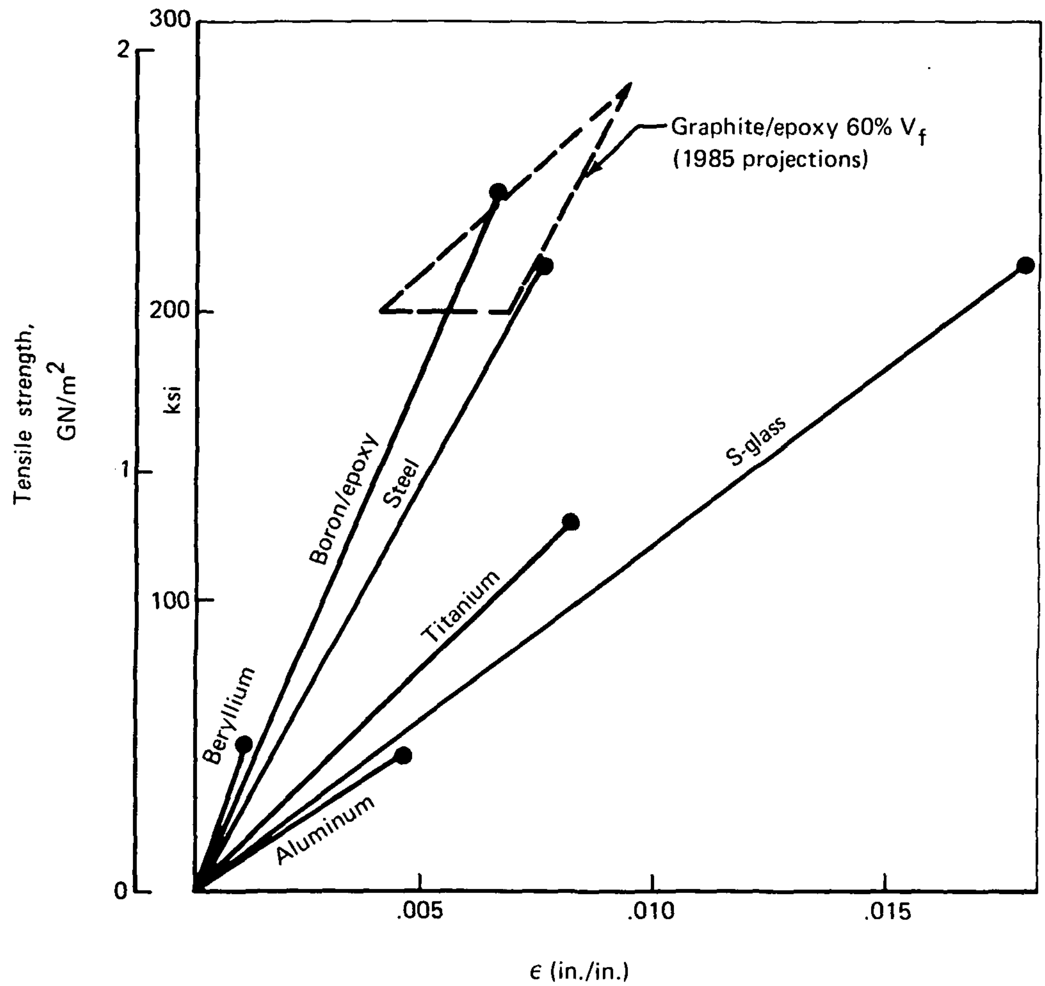


FIGURE 6-18.--PROPORTIONAL LIMITS OF STRUCTURAL MATERIALS

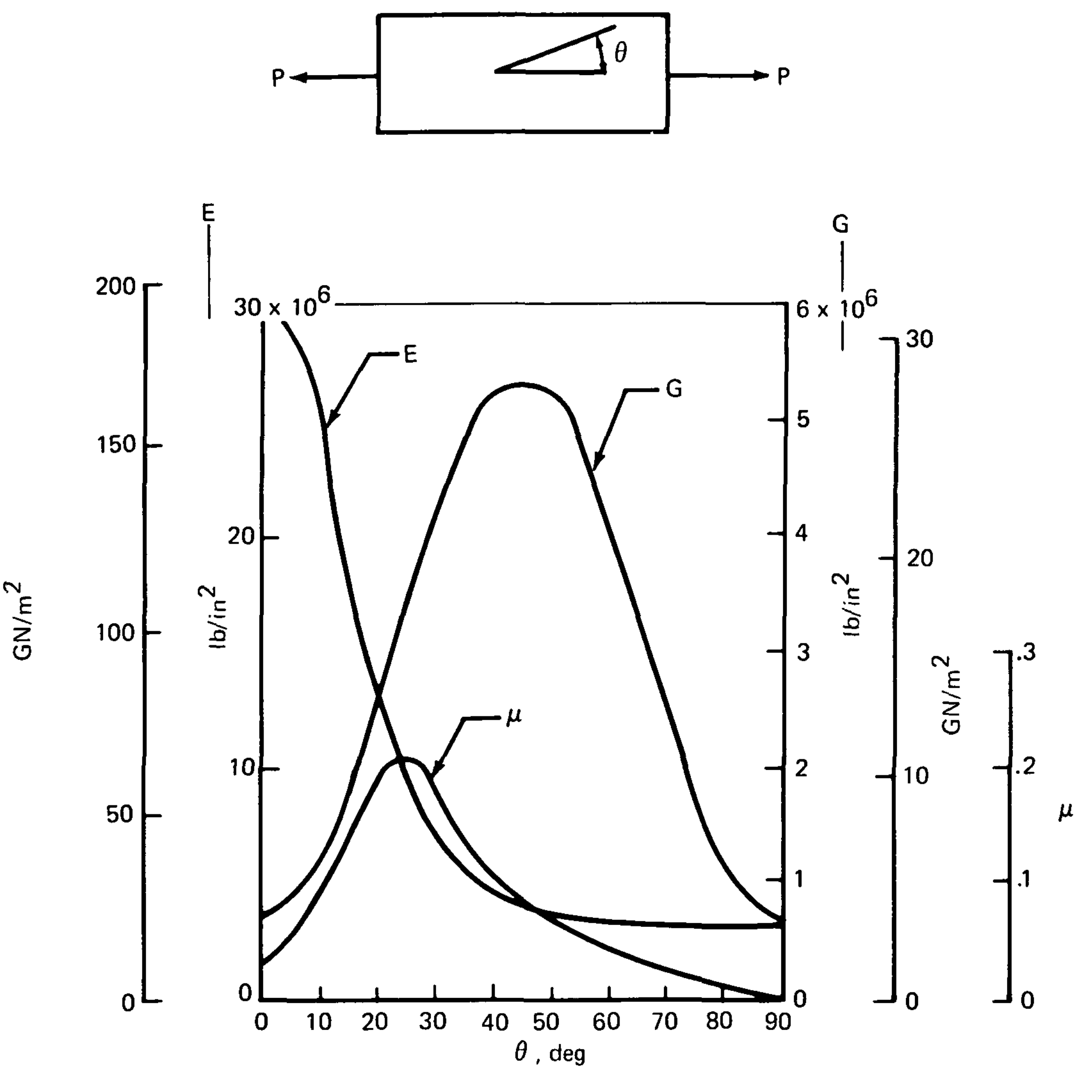


FIGURE 6-19.--CROSS-LAMINATED GRAPHITE FILAMENTS AT ±θ—
TYPICAL PREDICTED VALUES

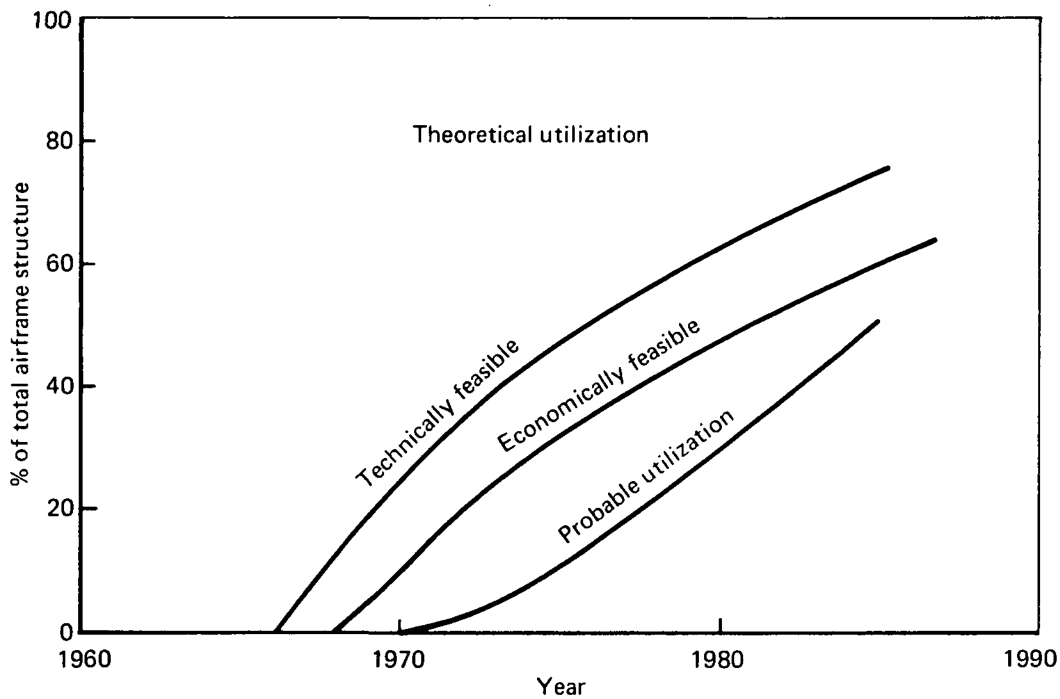


FIGURE 6-20.—GRAPHITE/EPOXY UTILIZATION

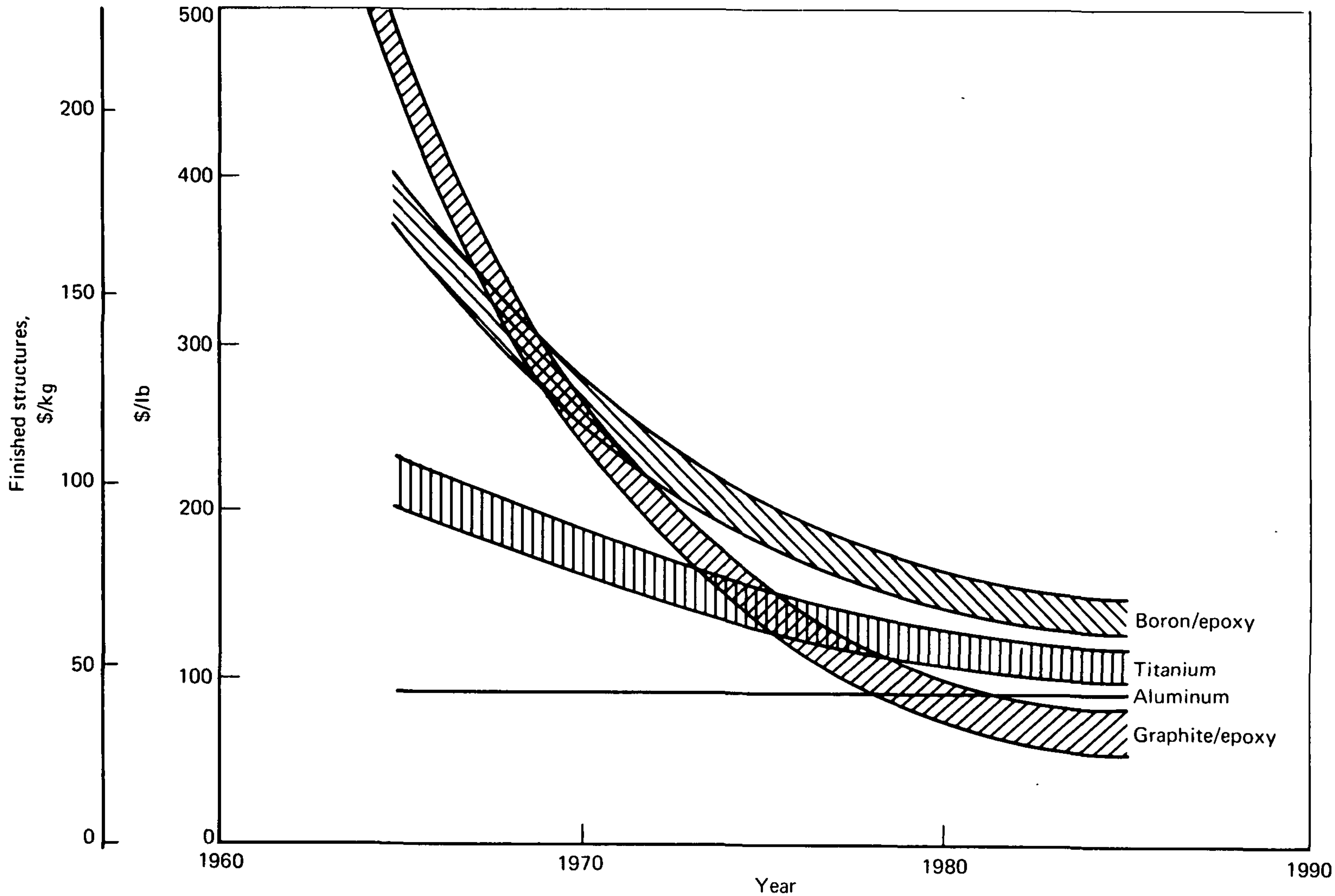


FIGURE 6-21.--PROJECTED FABRICATION COST OF STRUCTURAL MATERIALS--1970 CONSTANT DOLLARS

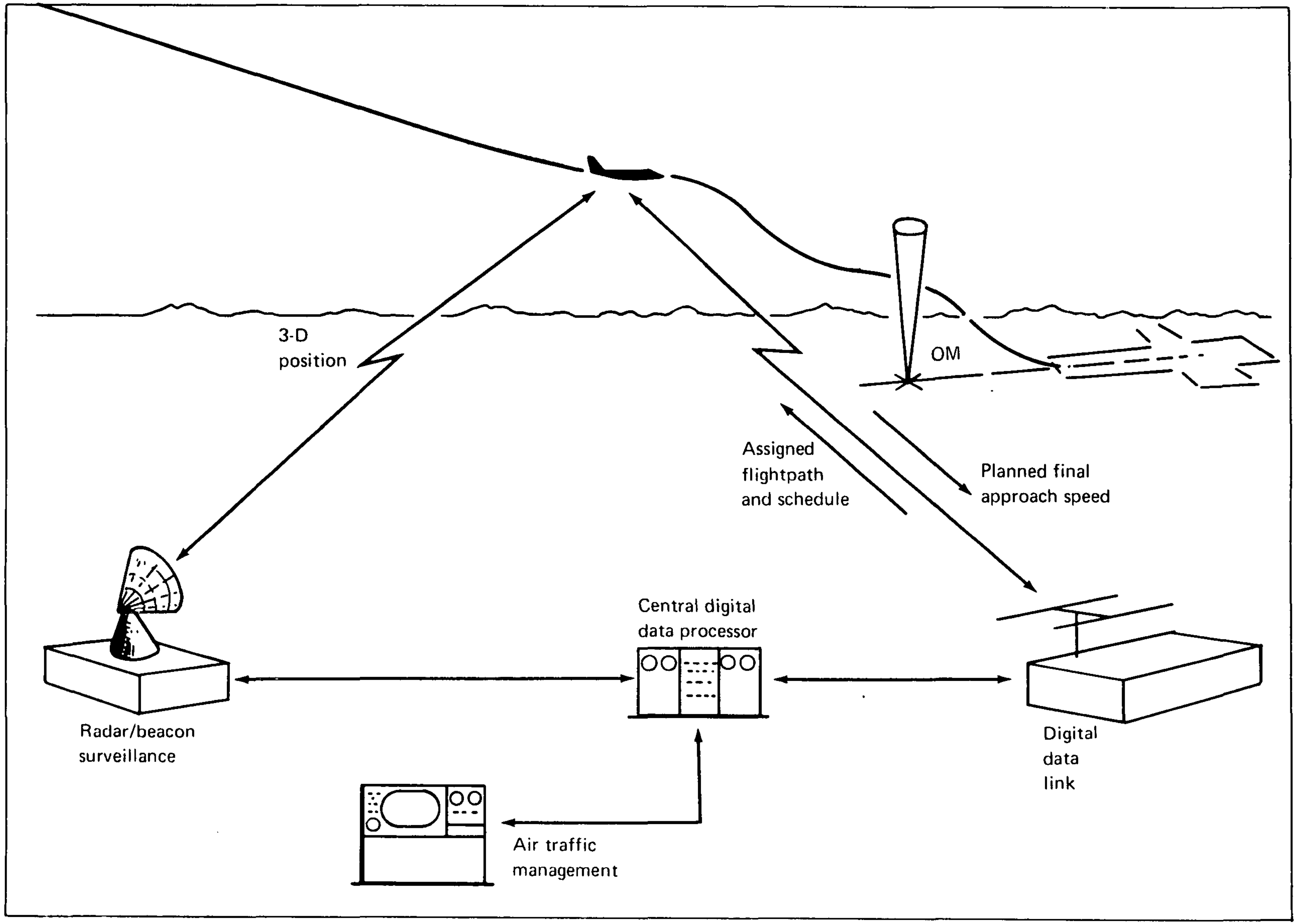


FIGURE 6-22.- ATC SYSTEM

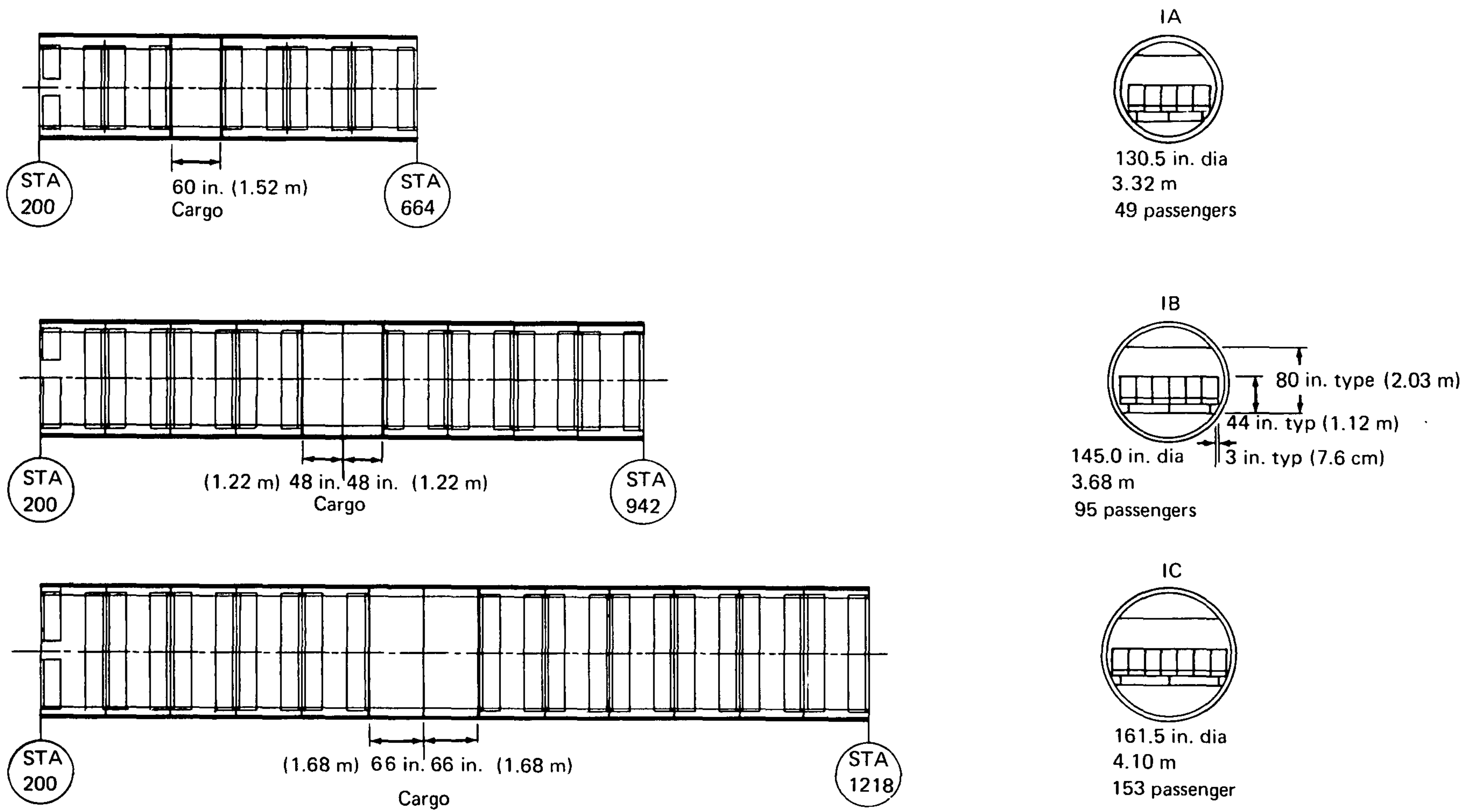


FIGURE 6-23.—INTERIOR LAYOUT—TYPE I

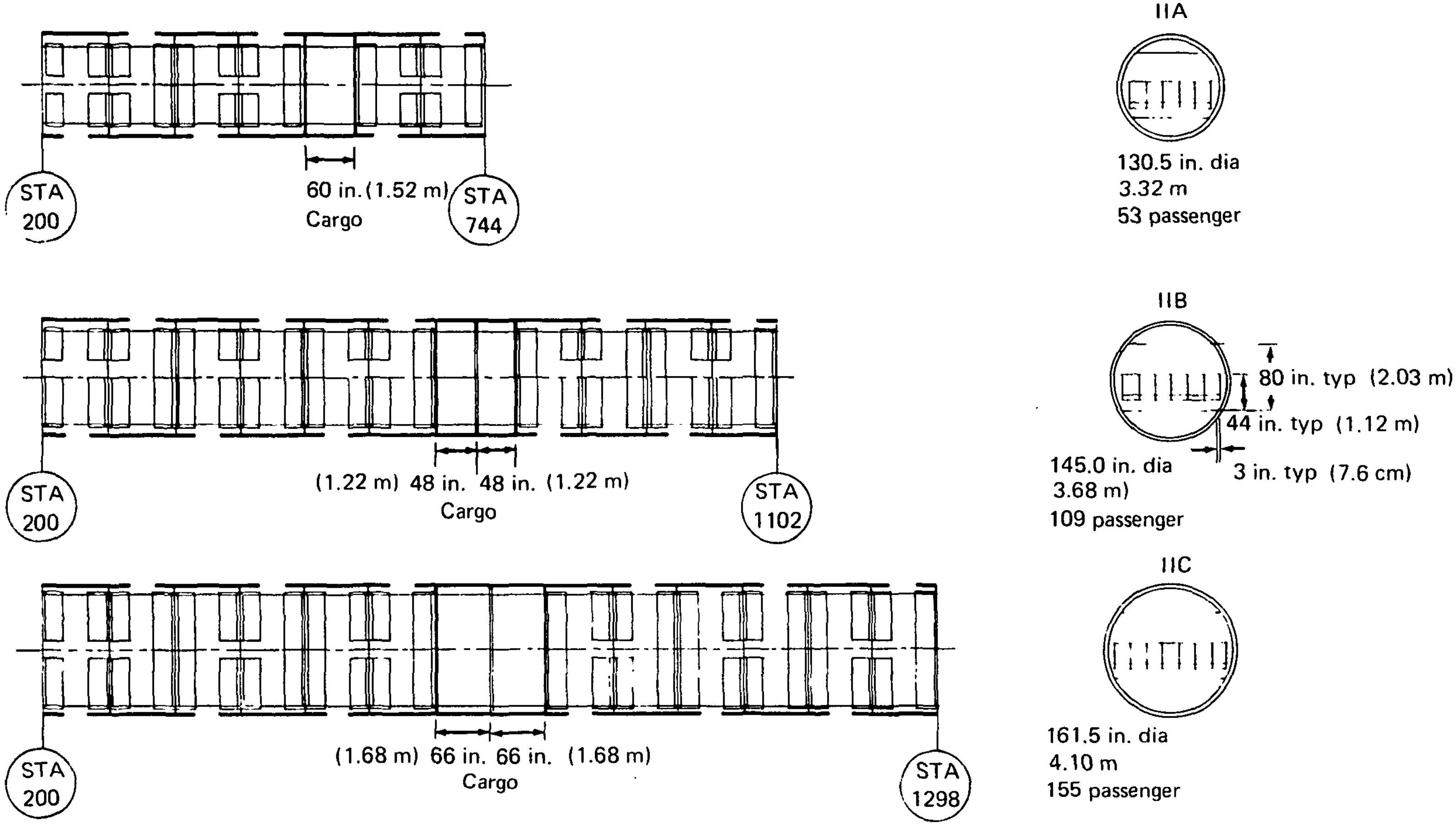


FIGURE 6-24.—INTERIOR LAYOUT, TYPE II

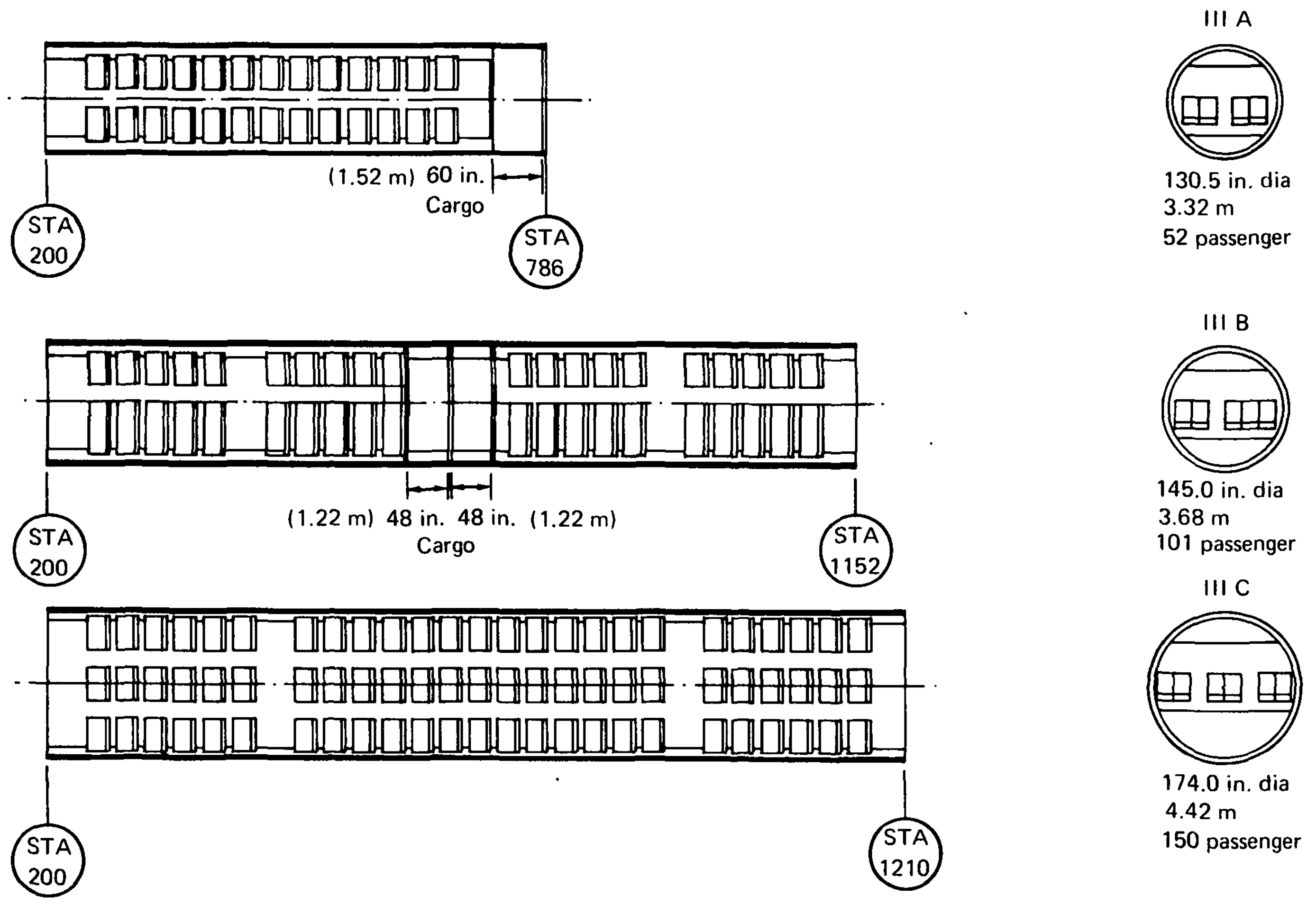


FIGURE 6-25.– INTERIOR LAYOUT, TYPE III

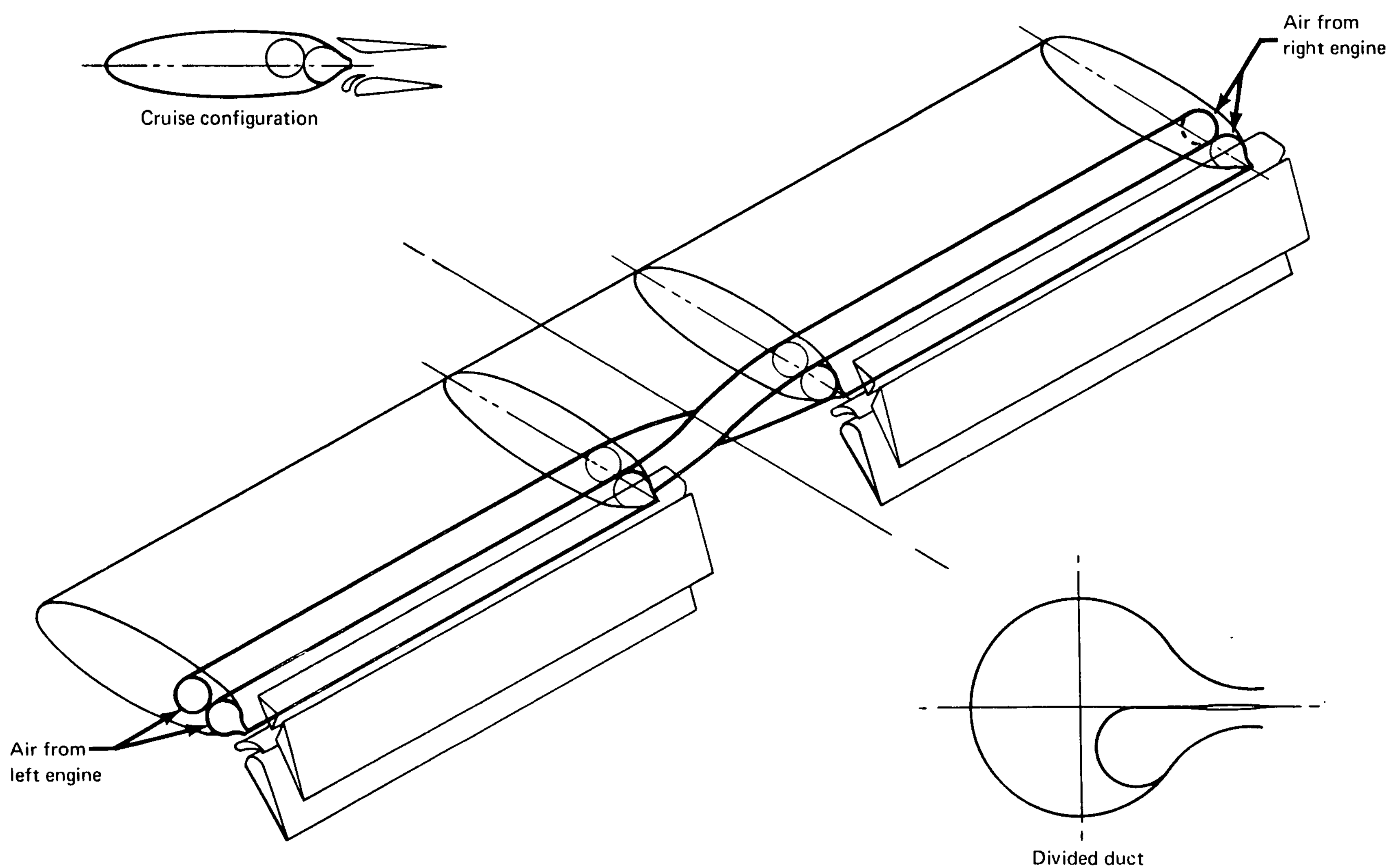


FIGURE 6-26.–SCHEMATIC DIAGRAM OF 1975 AUGMENTOR WING DUCT SYSTEM

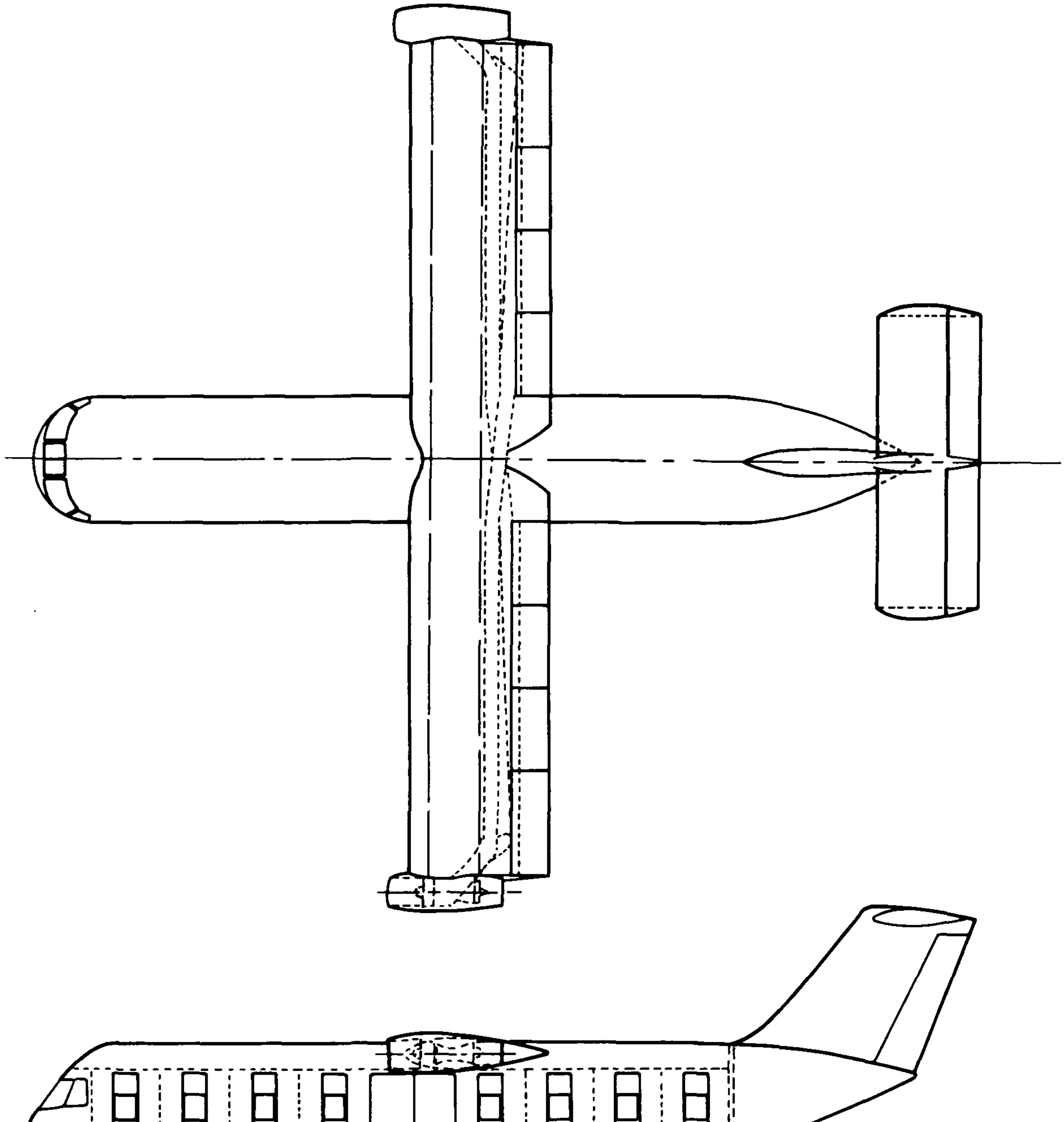


FIGURE 6-27.—1975 AUGMENTOR WING STOL GENERAL ARRANGEMENT, 95 PASSENGERS

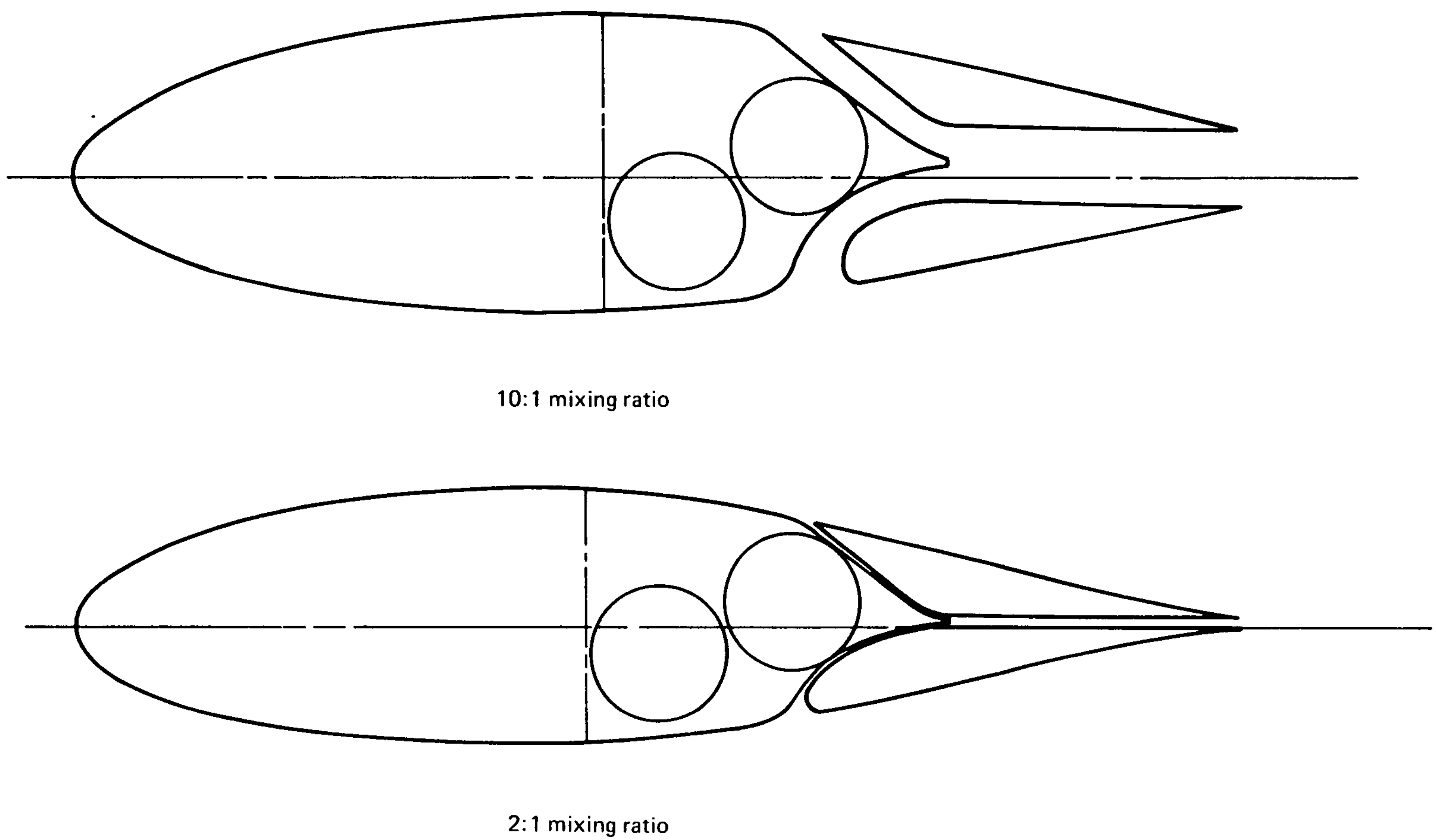


FIGURE 6-28.—EFFECT OF MIXING RATIO (CRUISE CONFIGURATION) ON WING CHORD GEOMETRY

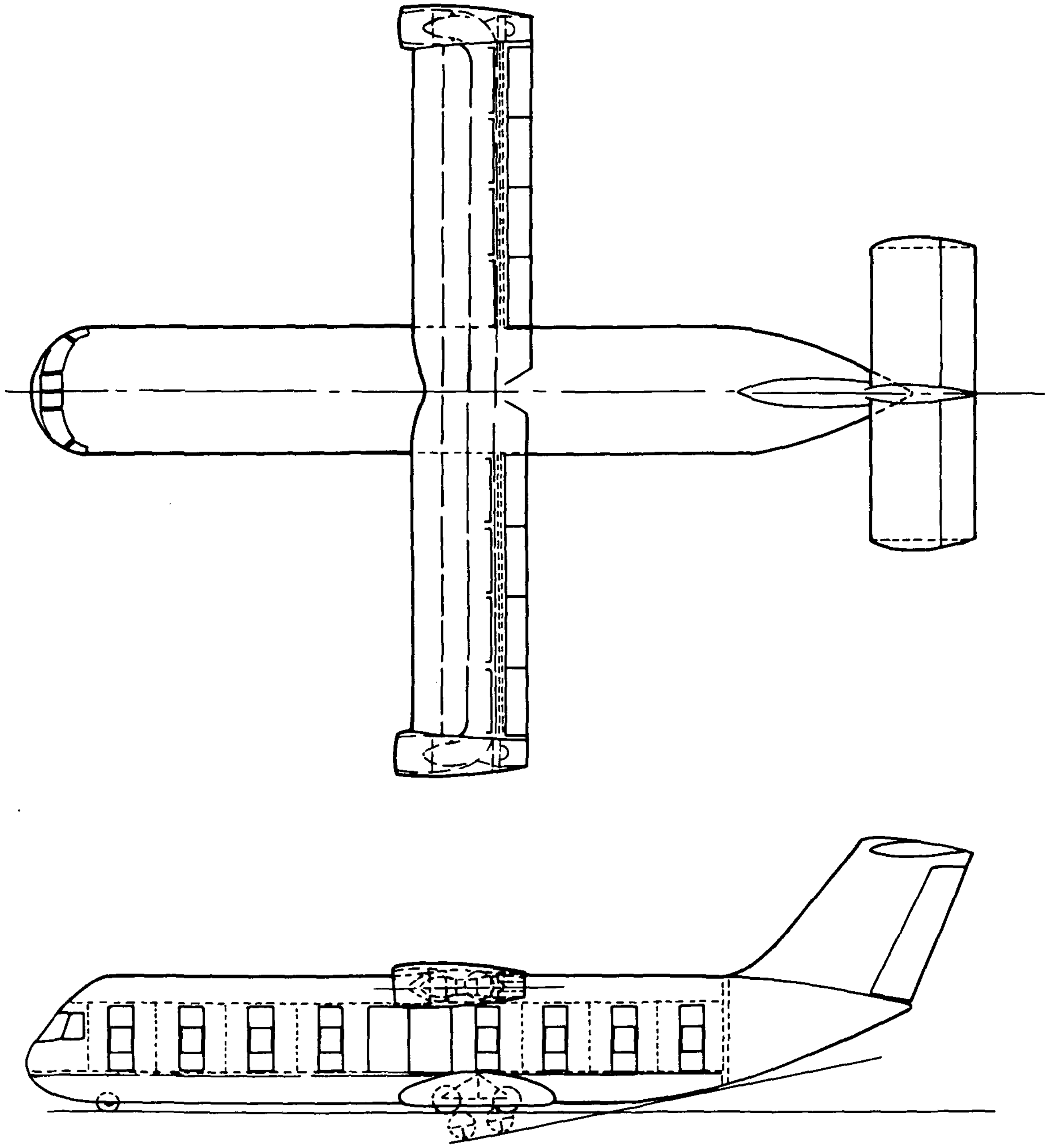


FIGURE 6-29.—1985 AUGMENTOR WING STOL GENERAL ARRANGEMENT, 95 PASSENGERS

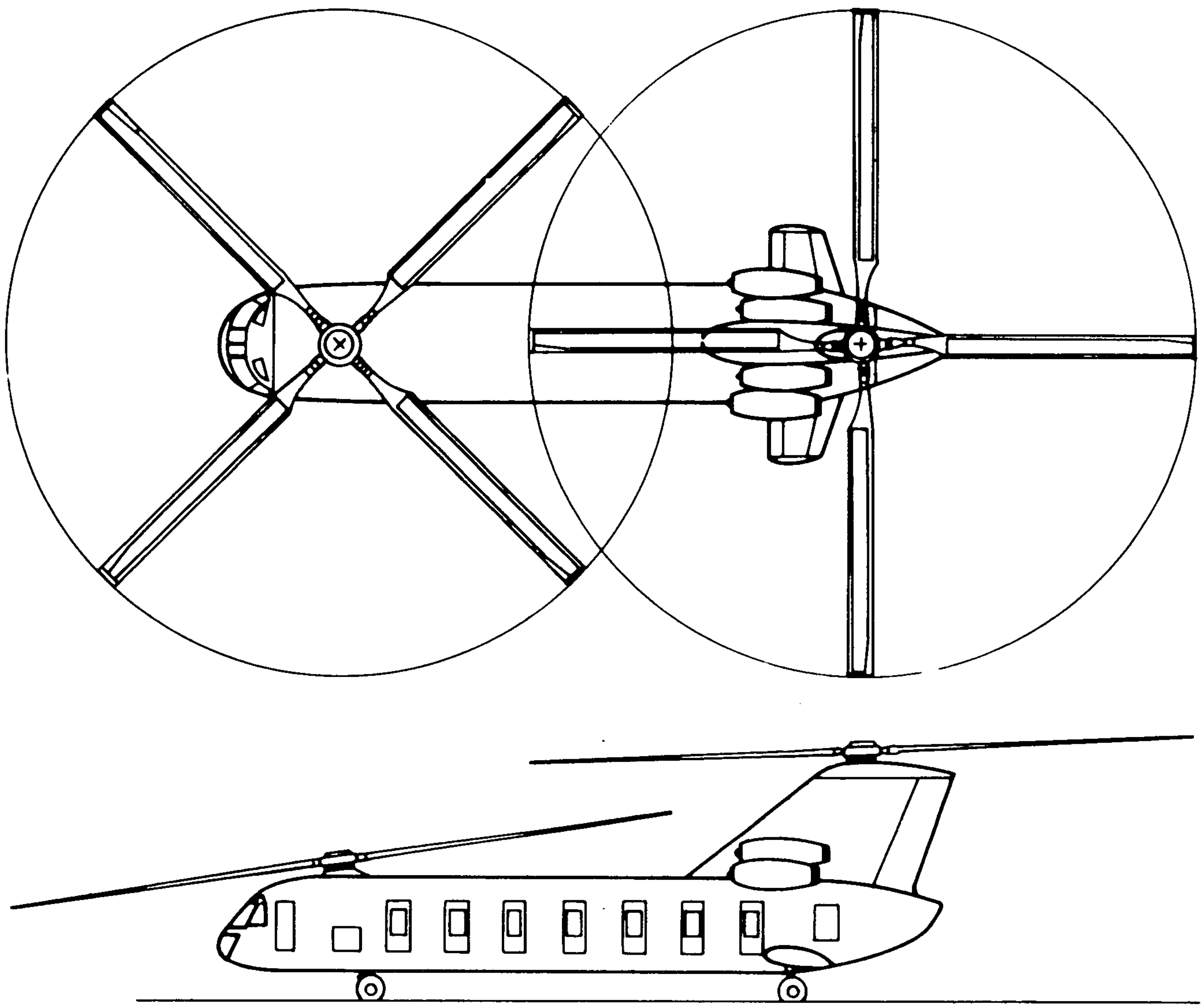


FIGURE 6-30.— 1975 HELICOPTER GENERAL ARRANGEMENT, 98 PASSENGERS

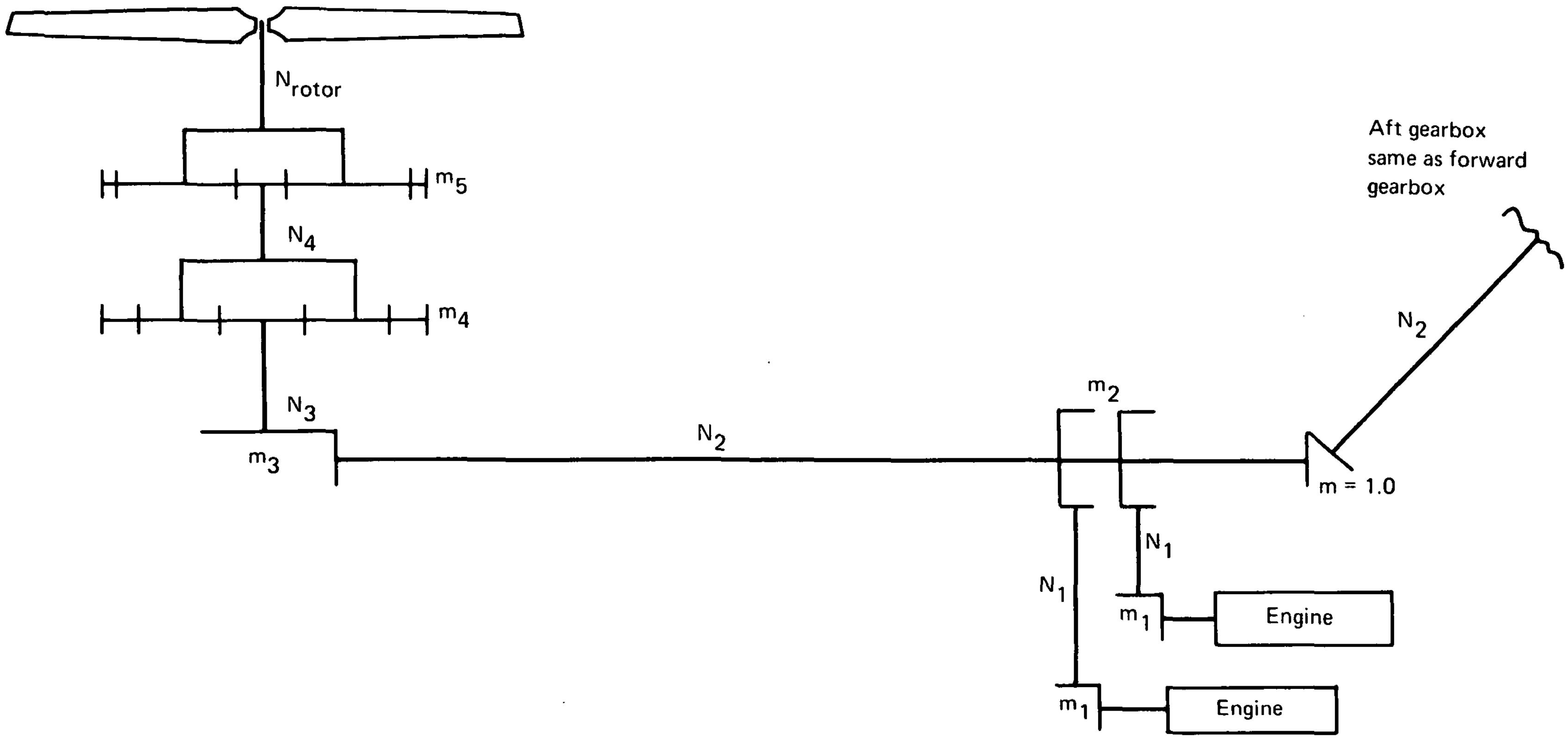


FIGURE 6-31.-- TRANSMISSION SYSTEM SCHEMATIC FOR HELICOPTERS

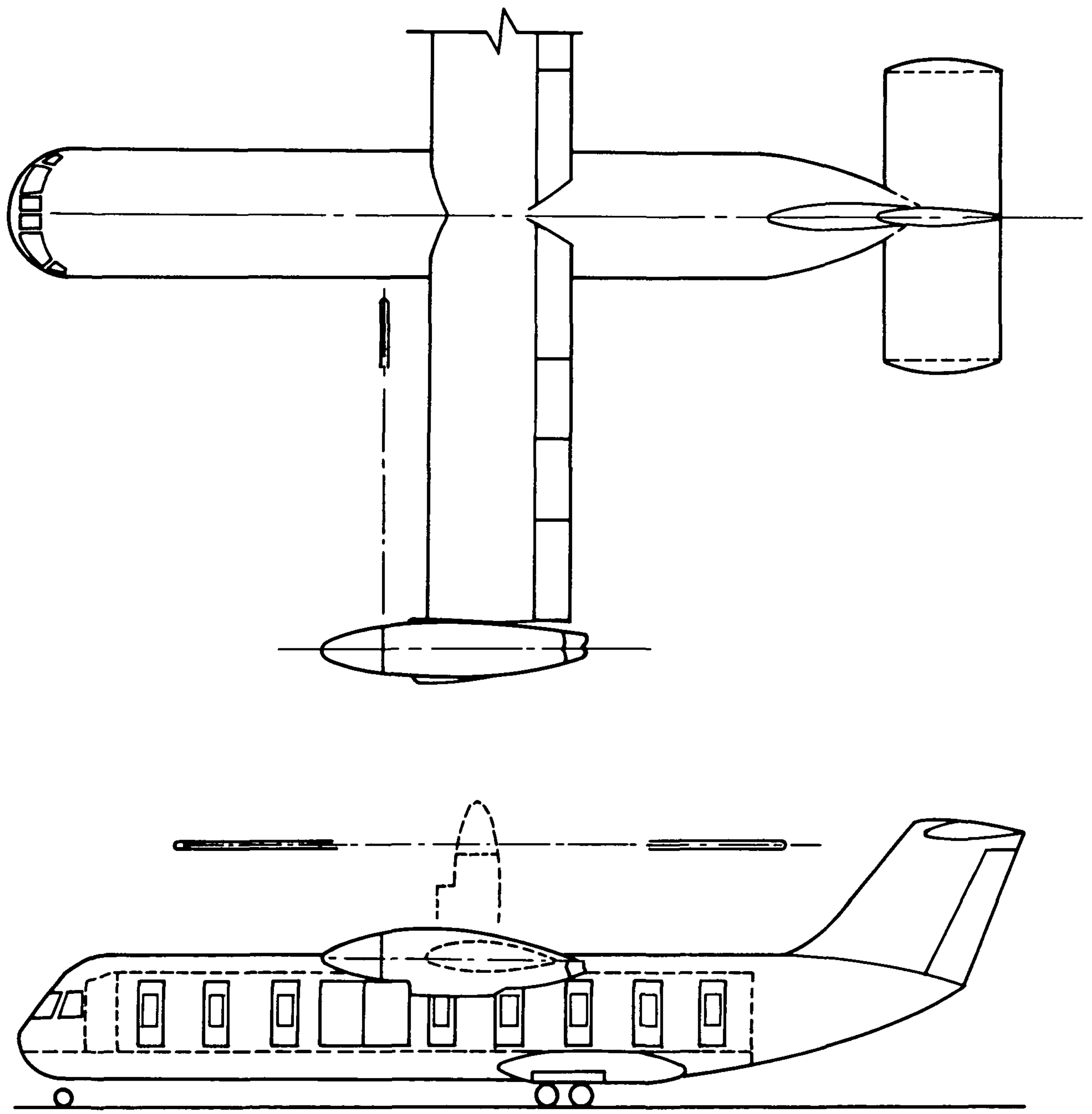


FIGURE 6-32.—1985 TILT ROTOR GENERAL ARRANGEMENT—100 PASSENGERS

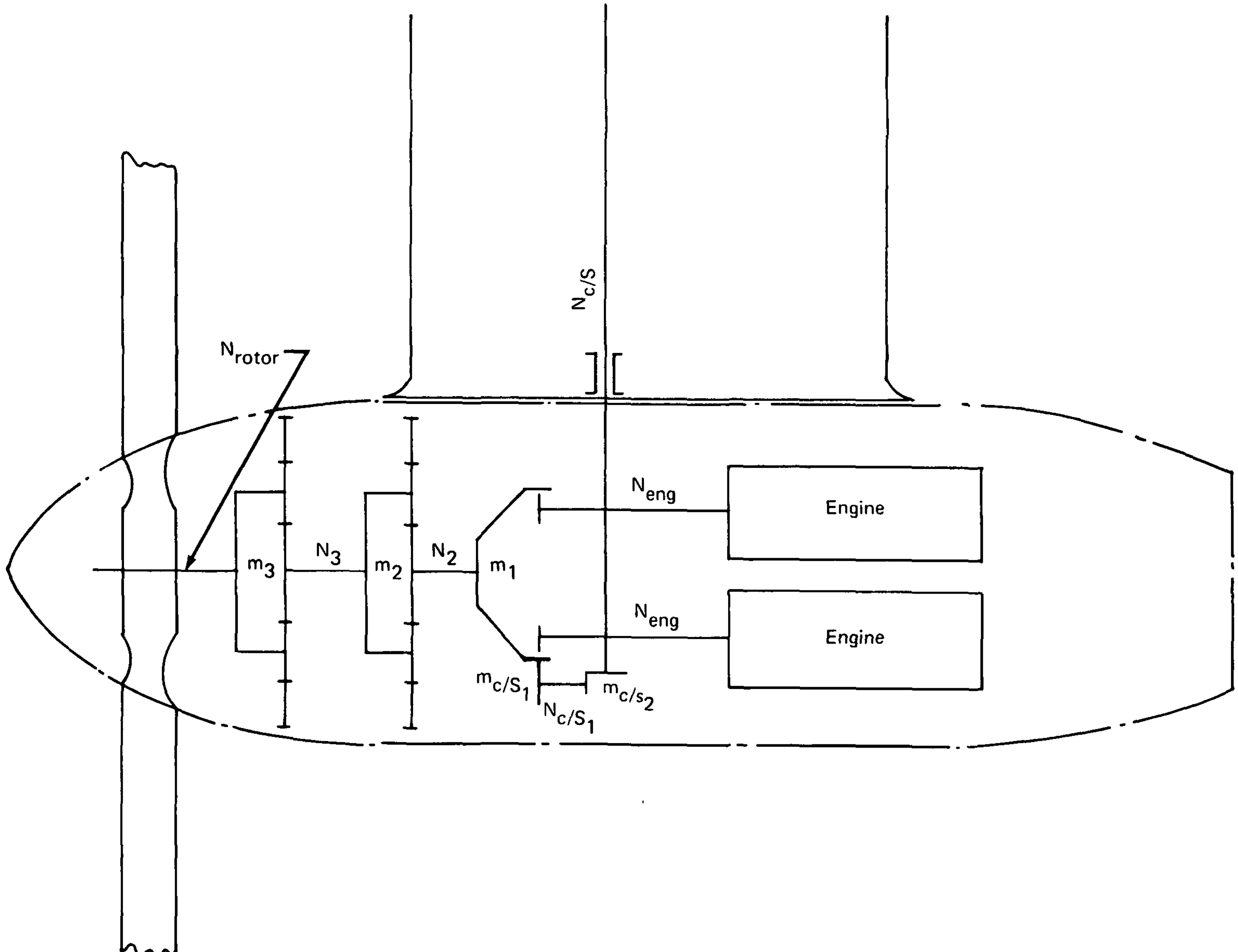


FIGURE 6-33.—TRANSMISSION SYSTEM SCHEMATIC FOR TILT-ROTOR VTOL

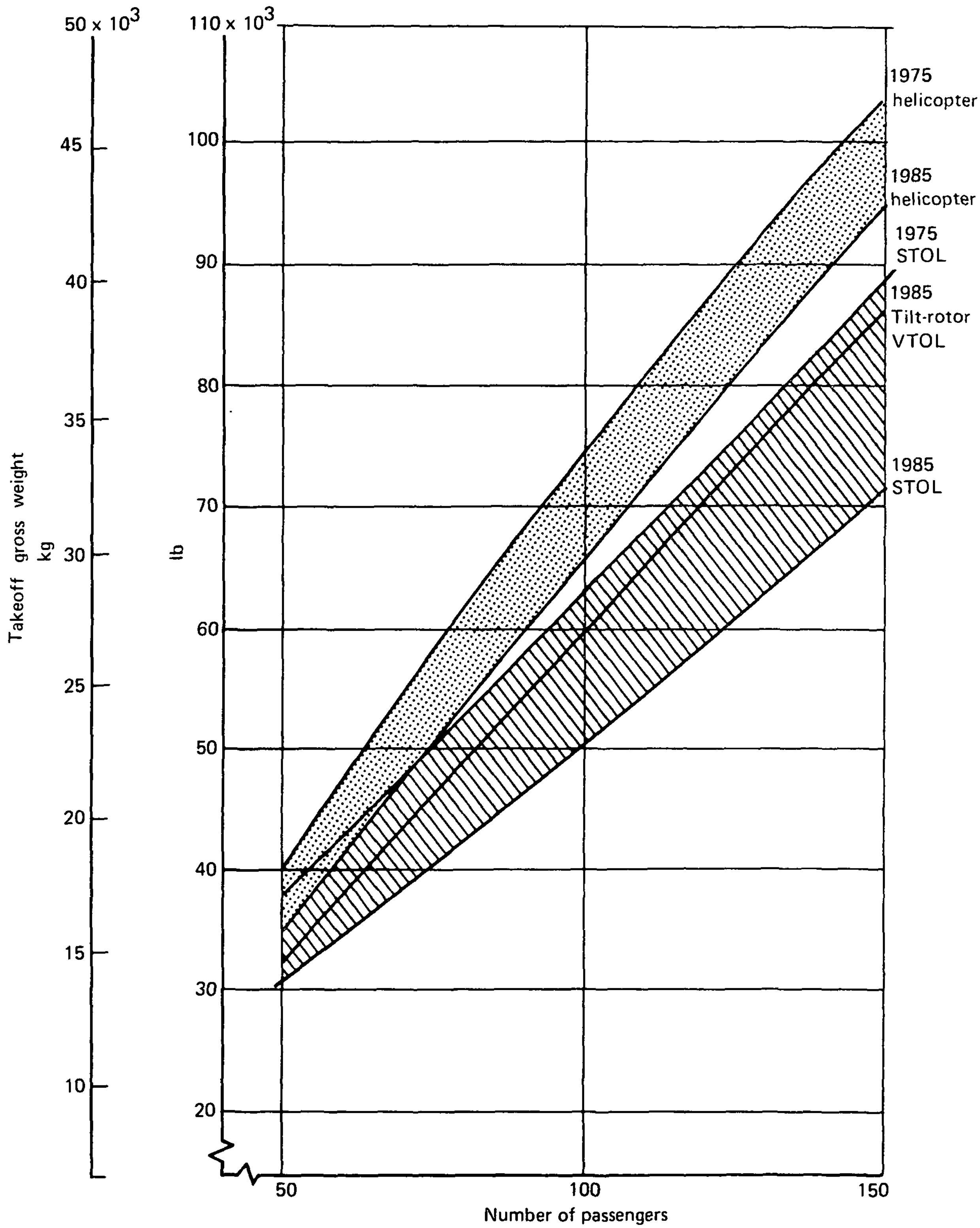


FIGURE 6-34.—TAKEOFF GROSS WEIGHT—BASELINE AIRPLANES

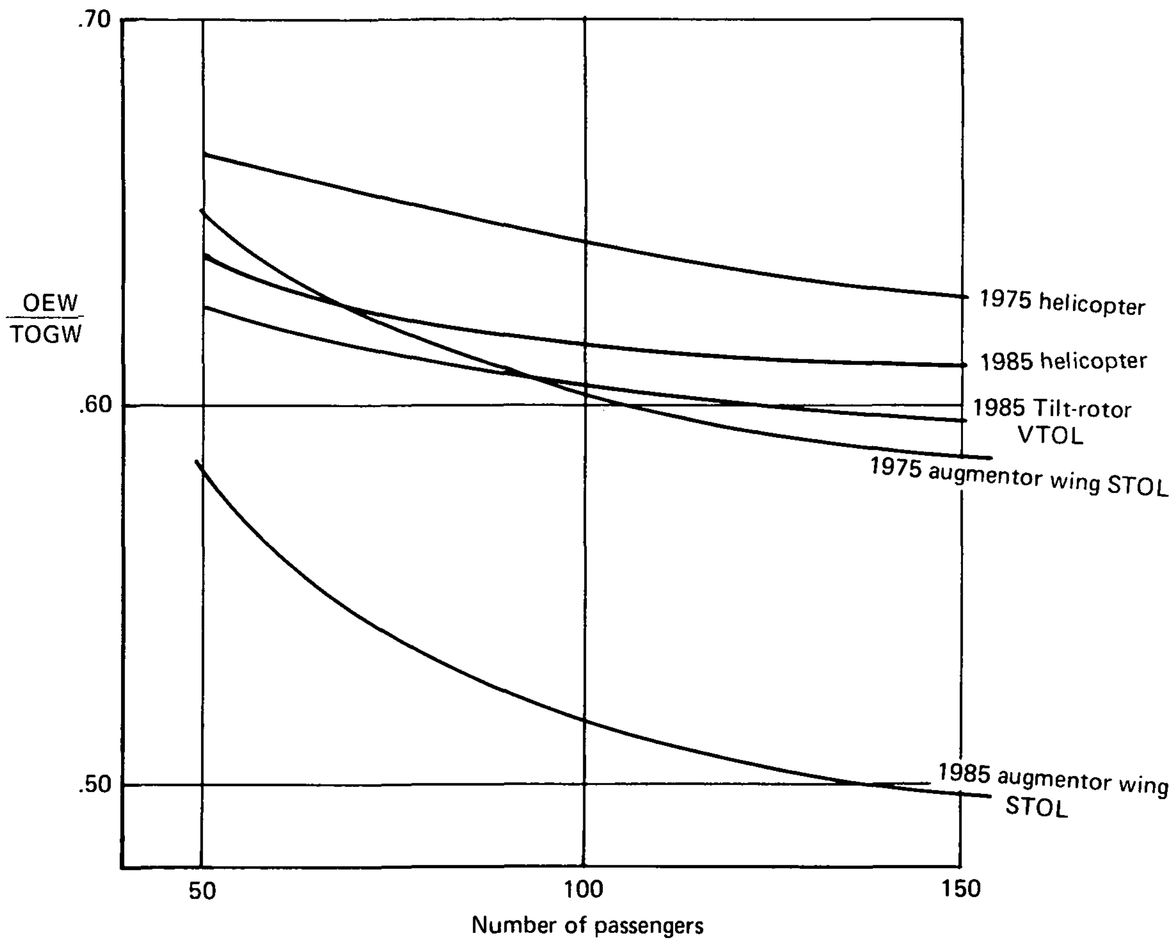


FIGURE 6-35.—OPERATIONAL EMPTY WEIGHT FRACTION—BASELINE AIRPLANES

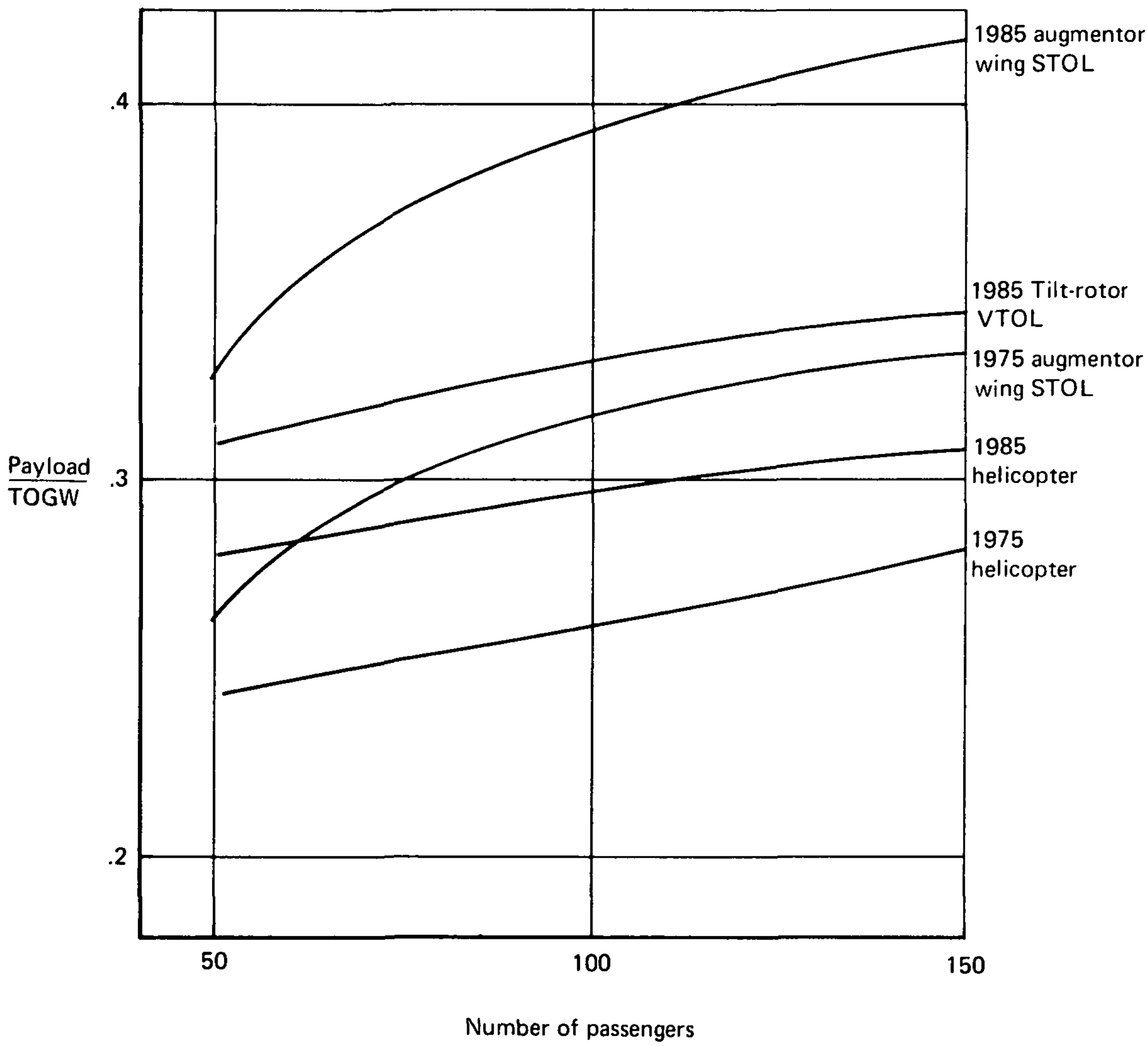


FIGURE 6-36.—PAYLOAD FRACTION, BASELINE AIRPLANES

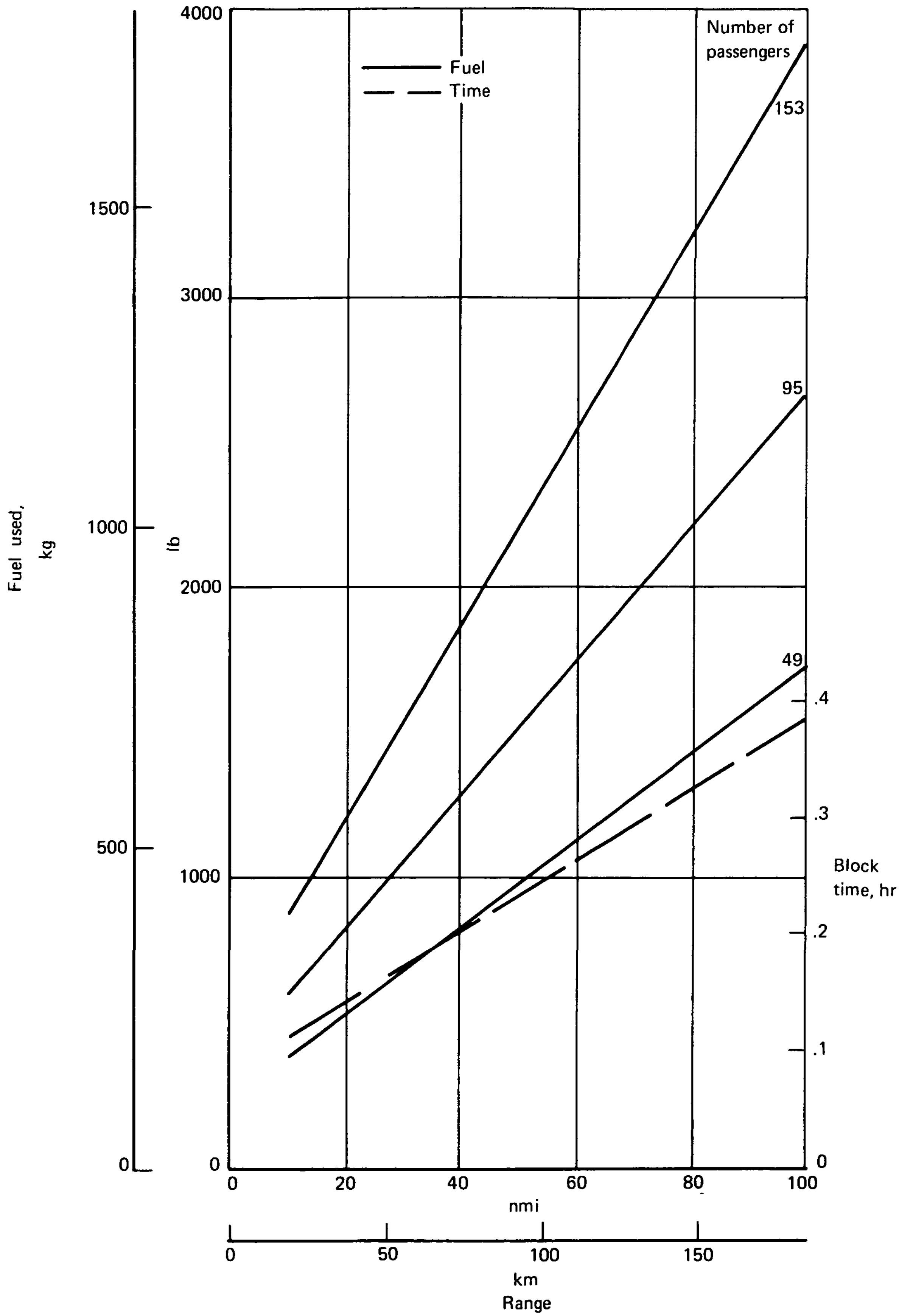


FIGURE 6-37.—1975 AUGMENTOR WING STOL FUEL USED, BASELINE AIRPLANES

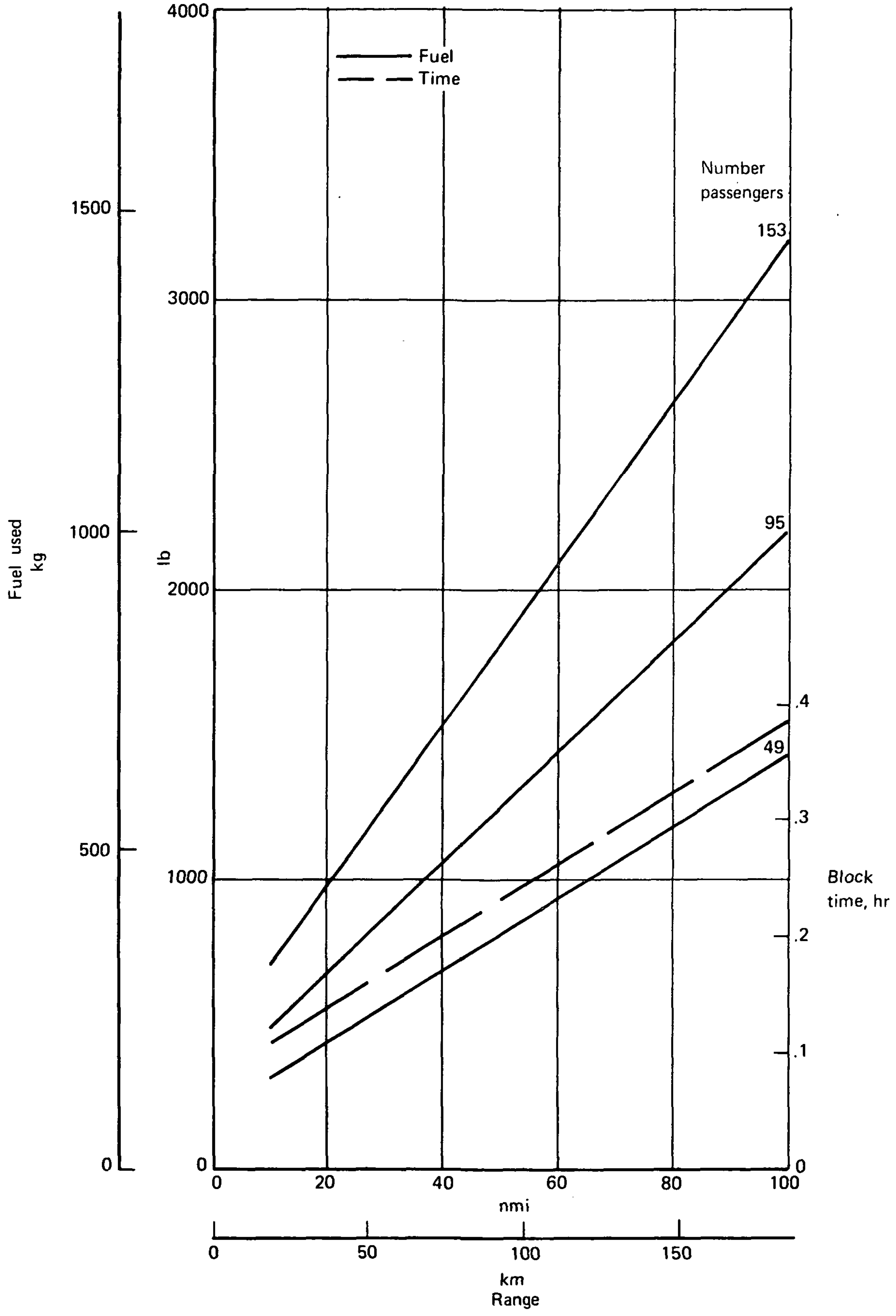


FIGURE 6-38.—1985 AUGMENTOR WING STOL FUEL USED, BASELINE AIRPLANES

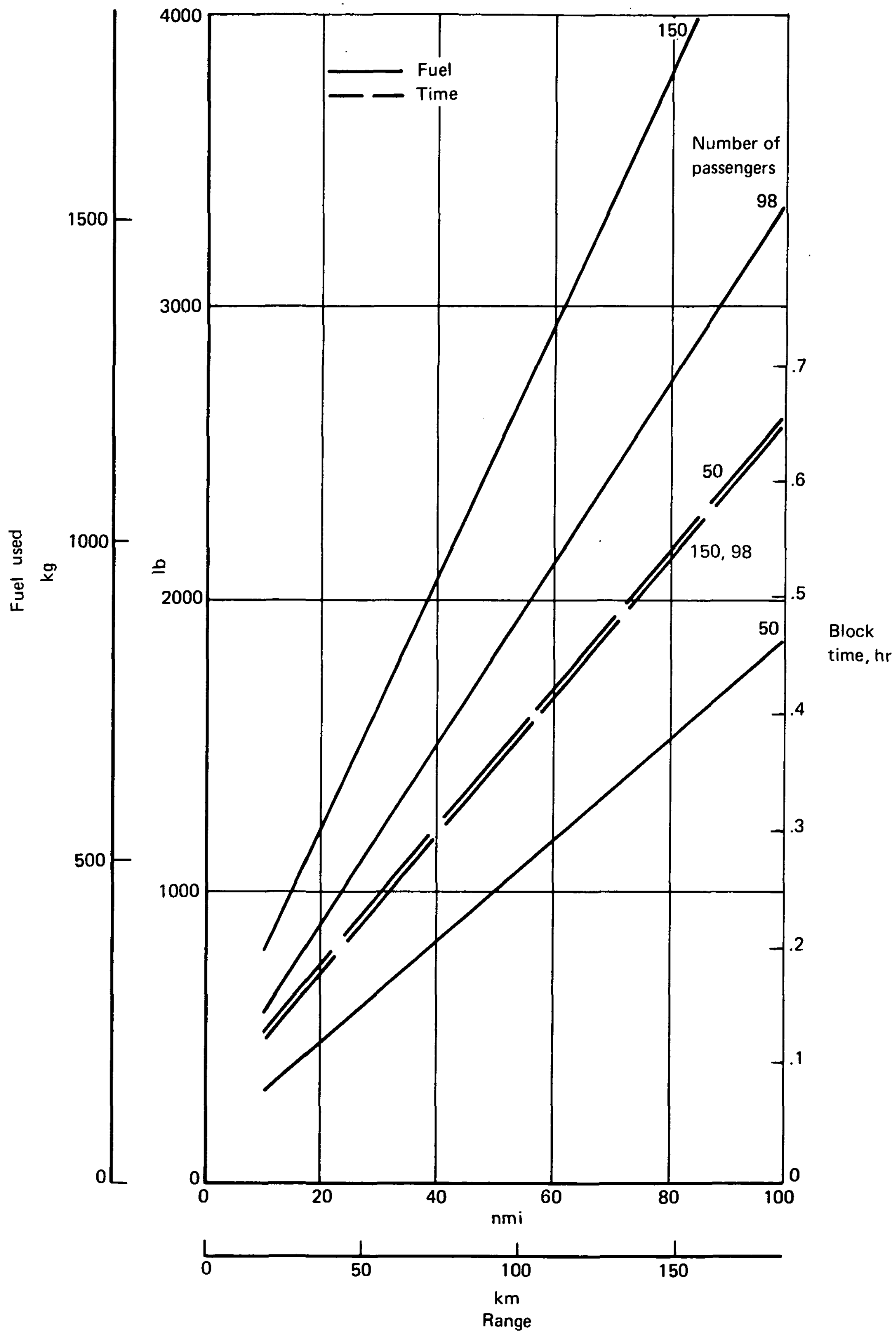


FIGURE 6-39.—1975 TANDEM ROTOR HELICOPTER FUEL USED, BASELINE AIRPLANES

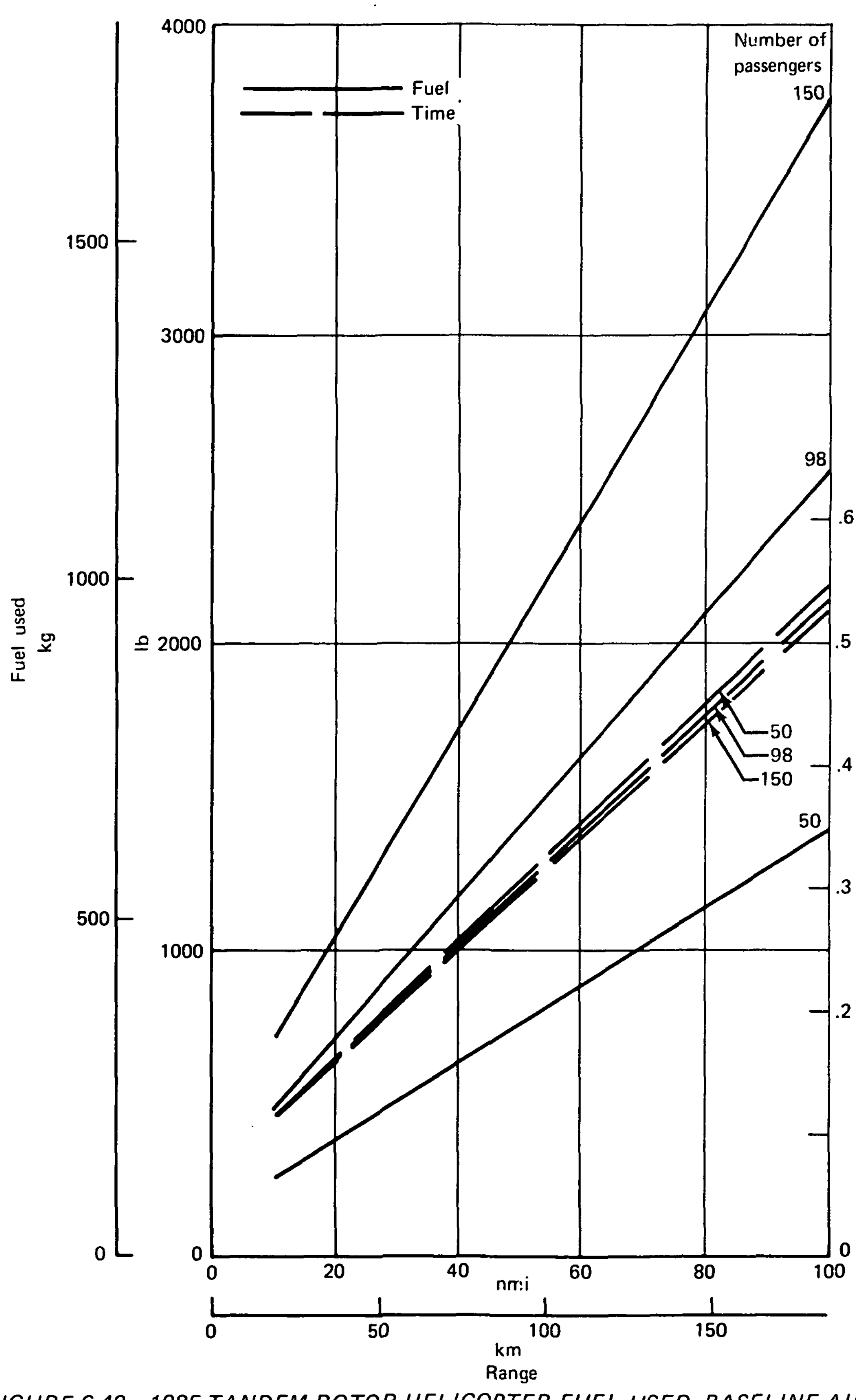


FIGURE 6-40.—1985 TANDEM-ROTOR HELICOPTER FUEL USED, BASELINE AIRPLANES

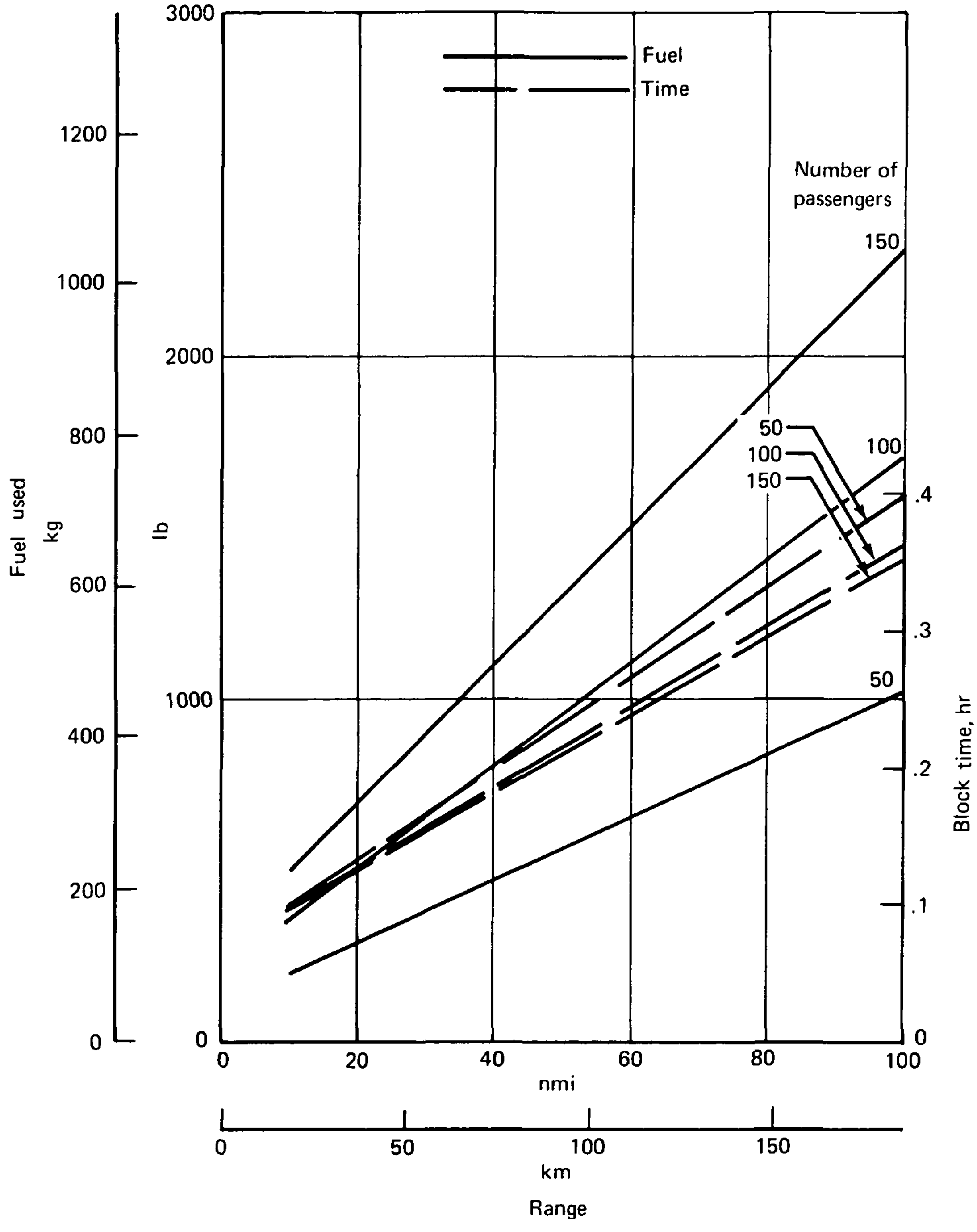


FIGURE 6-41.—1985 TILT-ROTOR VTOL FUEL USED, BASELINE AIRPLANES

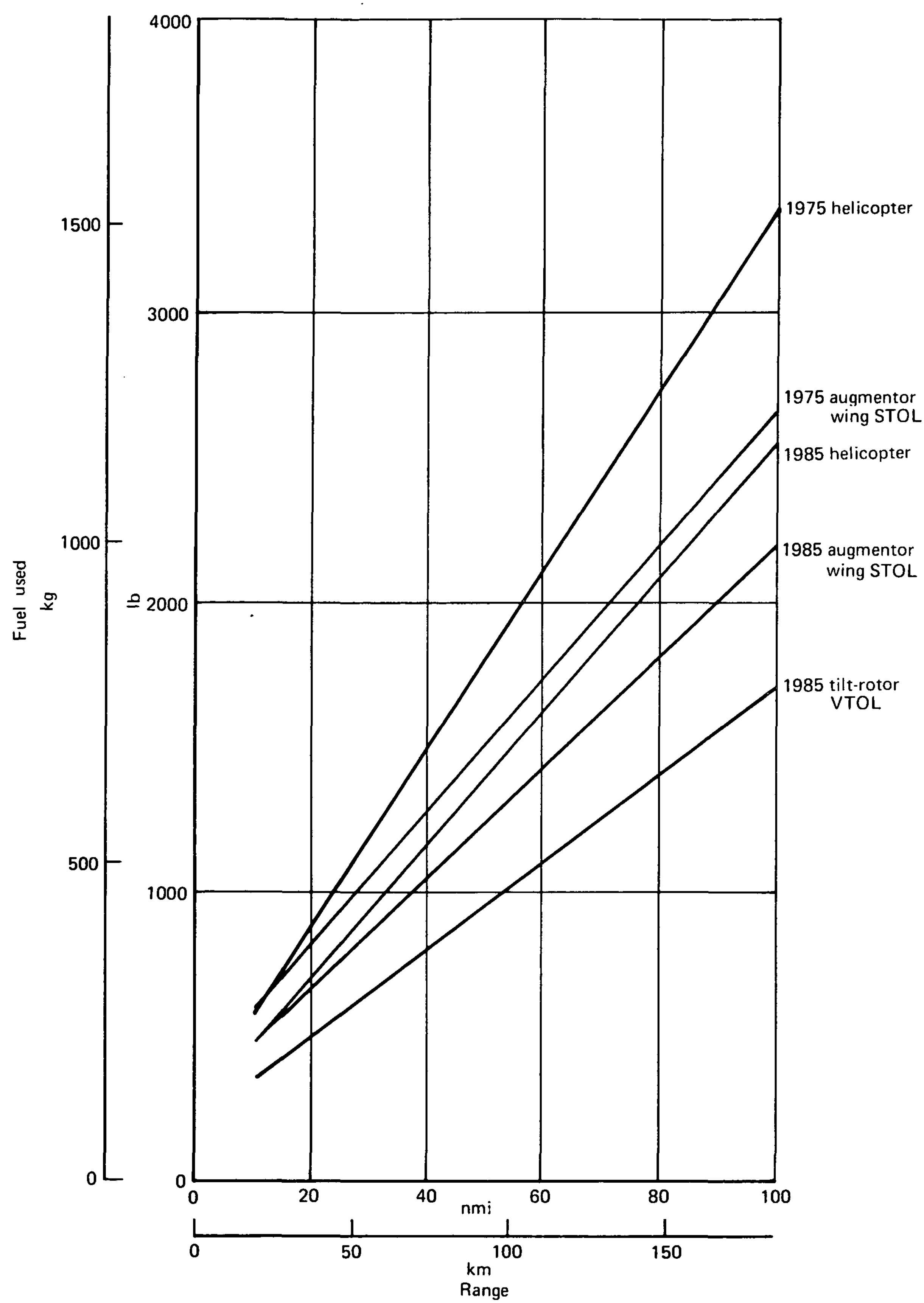


FIGURE 6-42.—BASELINE AIRPLANE FUEL USED, 100 PASSENGERS

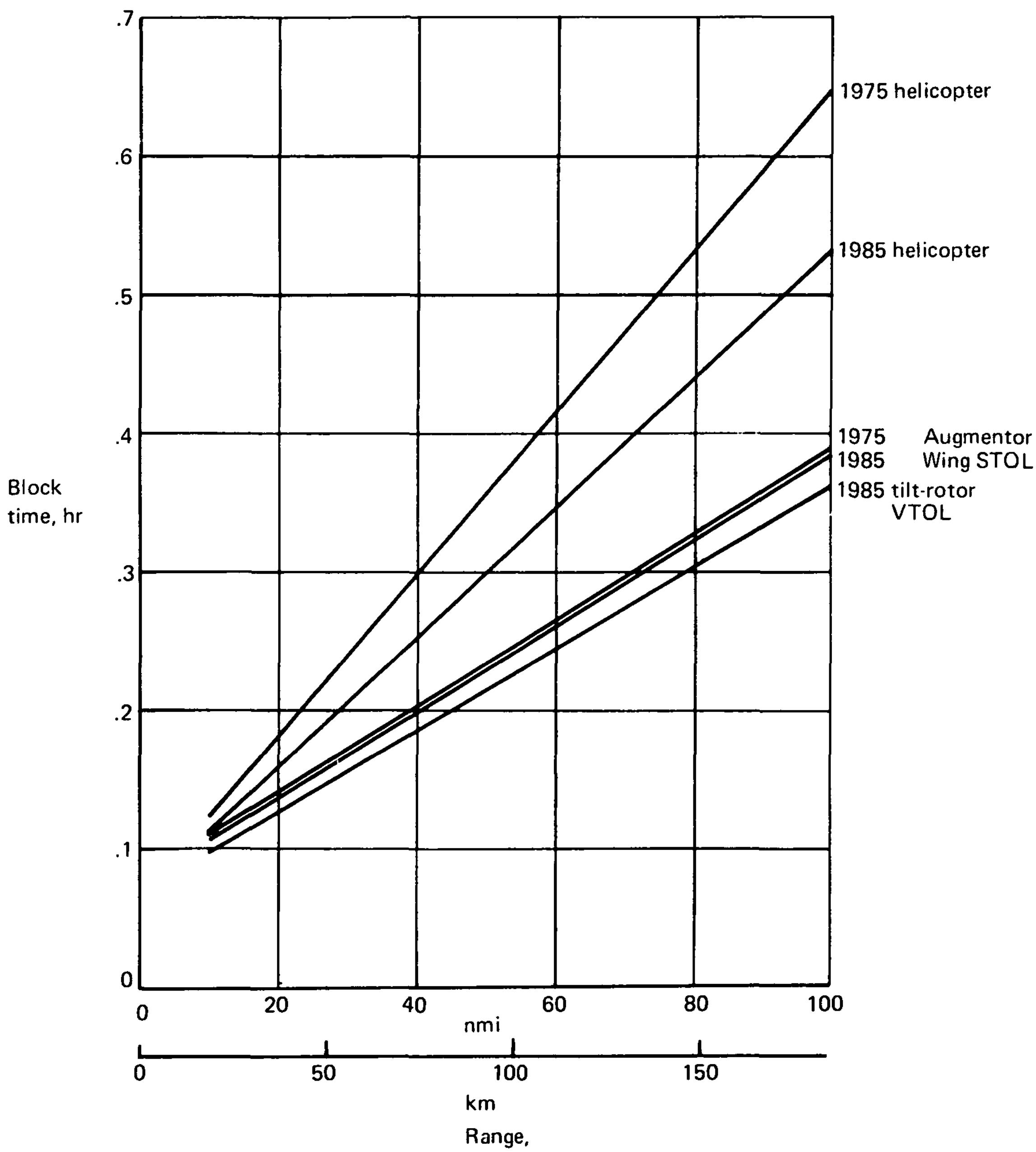


FIGURE 6-43.–BLOCK TIME FOR BASELINE AIRPLANES–100 PASSENGERS

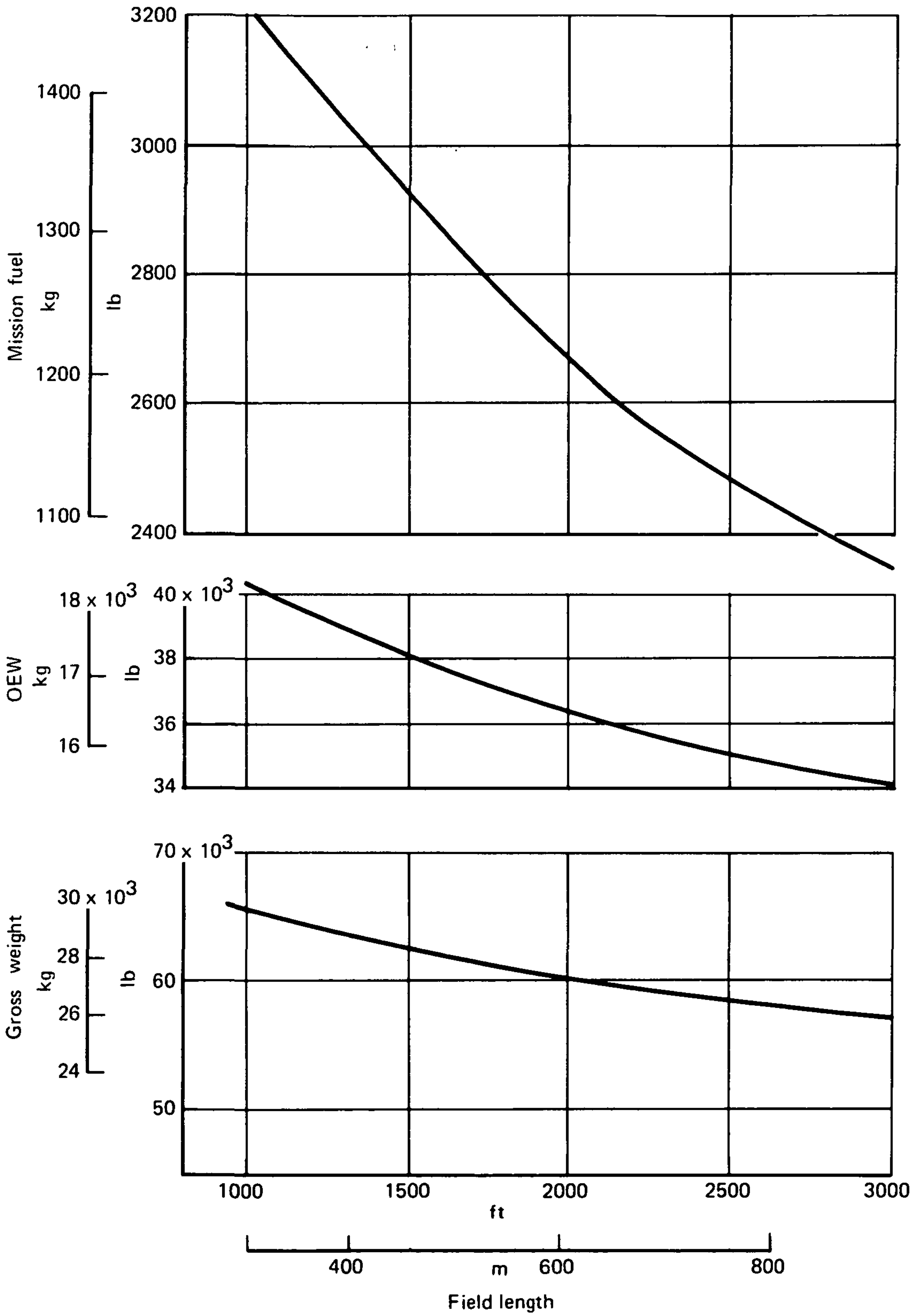


FIGURE 6-44.—SENSITIVITY TO DESIGN FIELD LENGTH—1975 AUGMENTOR WING STOL—95 PASSENGERS

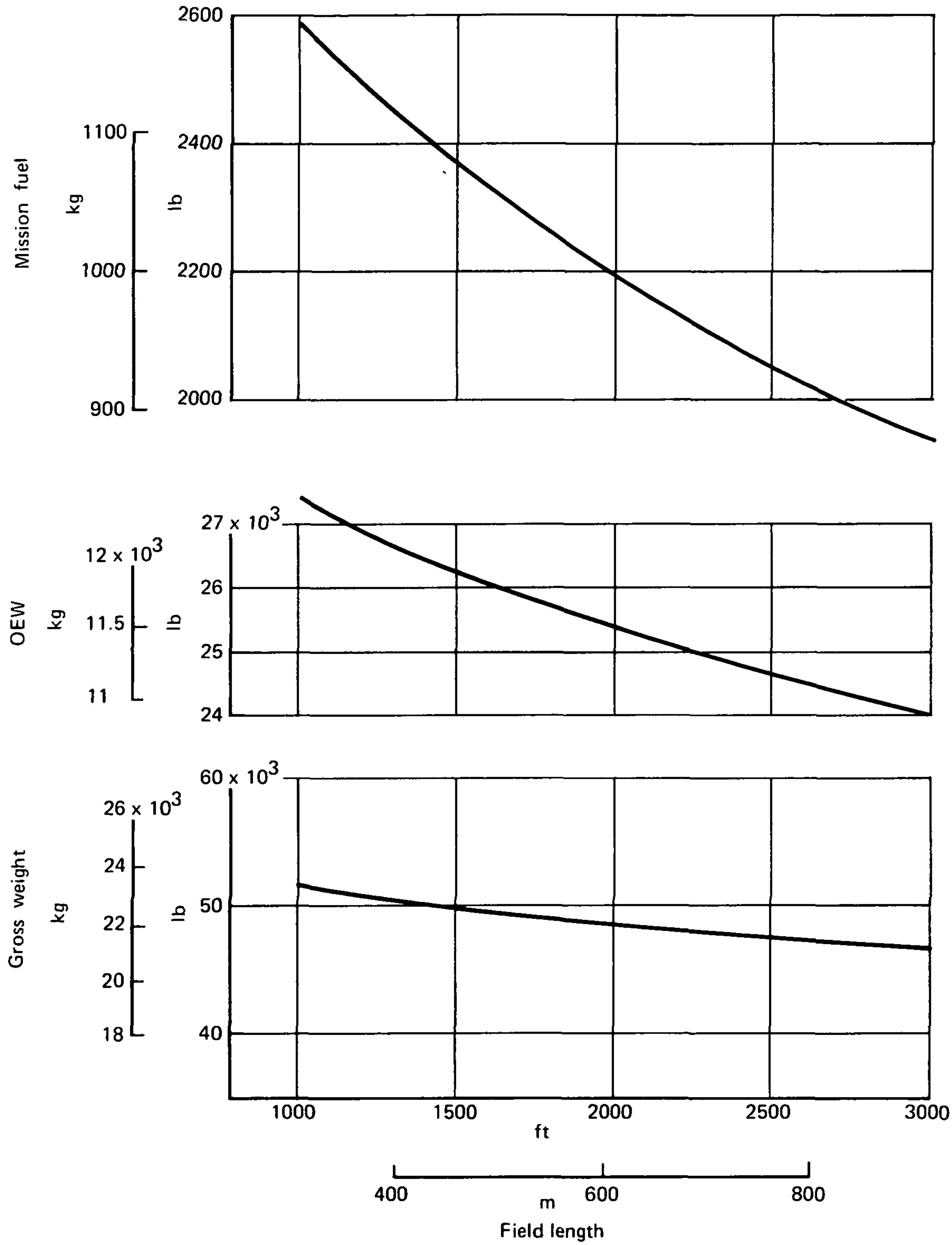


FIGURE 6-45.--SENSITIVITY TO DESIGN FIELD LENGTH—1985 AUGMENTOR WING STOL—95 PASSENGERS

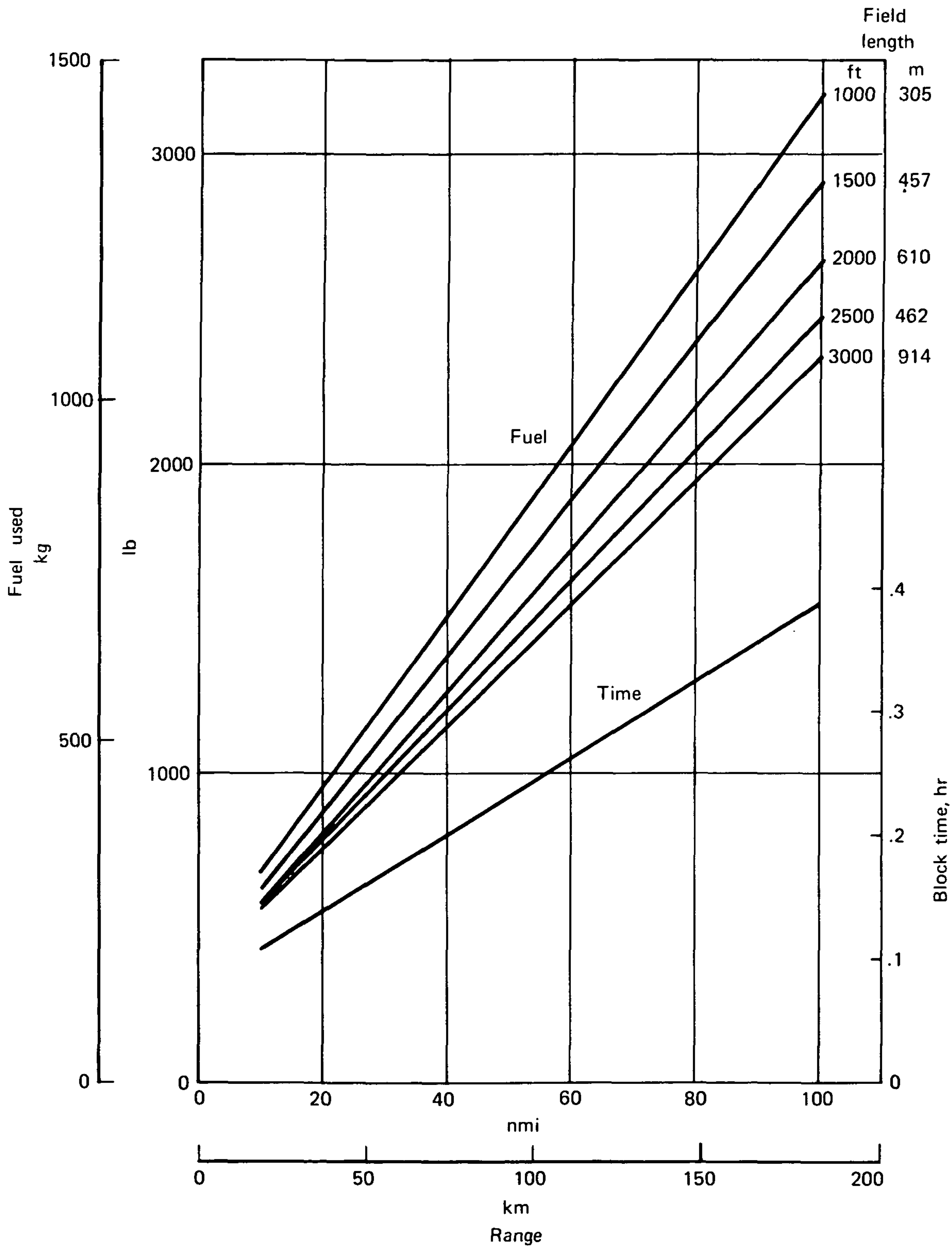


FIGURE 6-46.--1975 AUGMENTOR WING STOL FUEL USED, 95 PASSENGERS

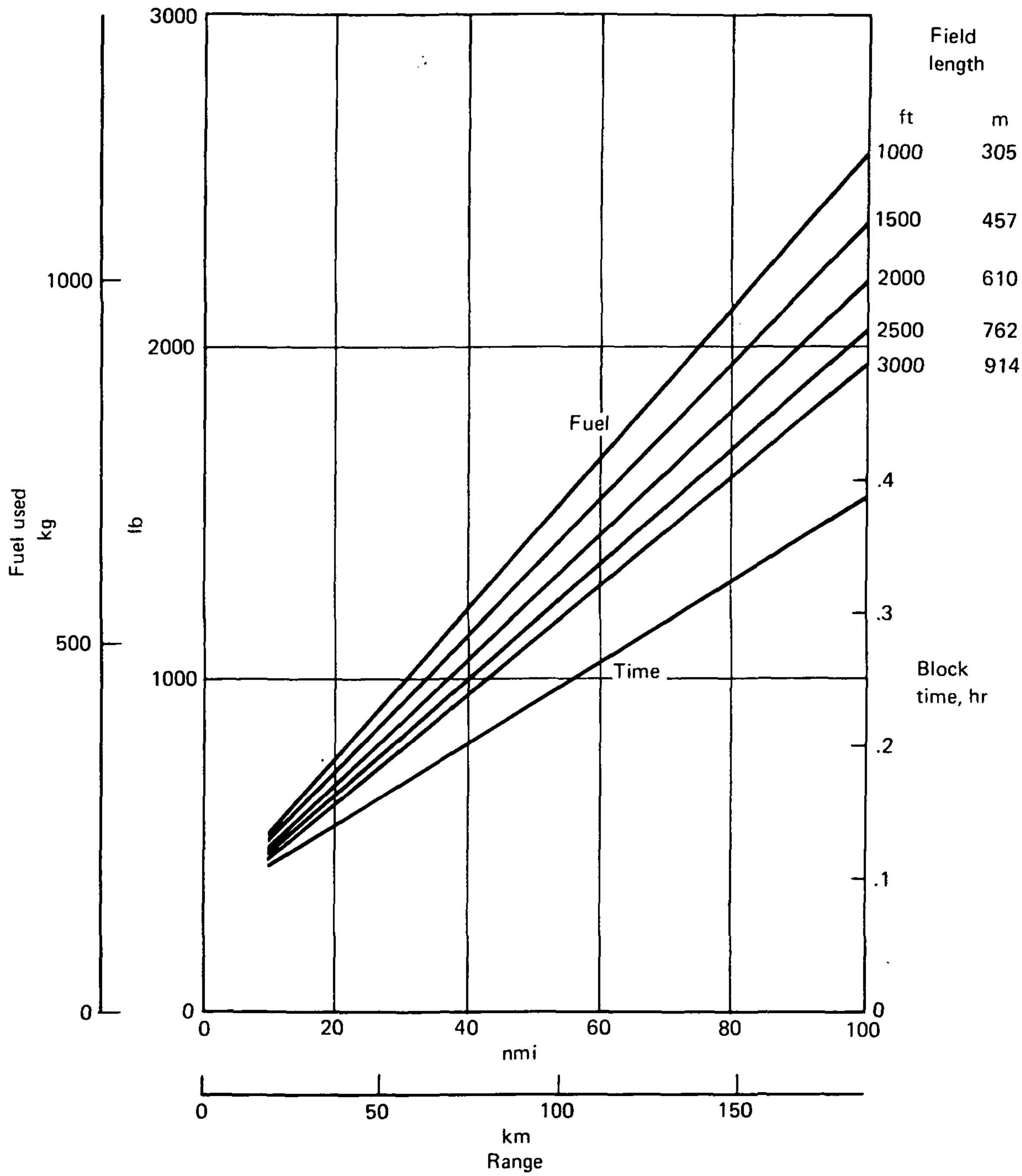


FIGURE 6-47.—1985 AUGMENTOR WING STOL FUEL USED, 95 PASSENGERS

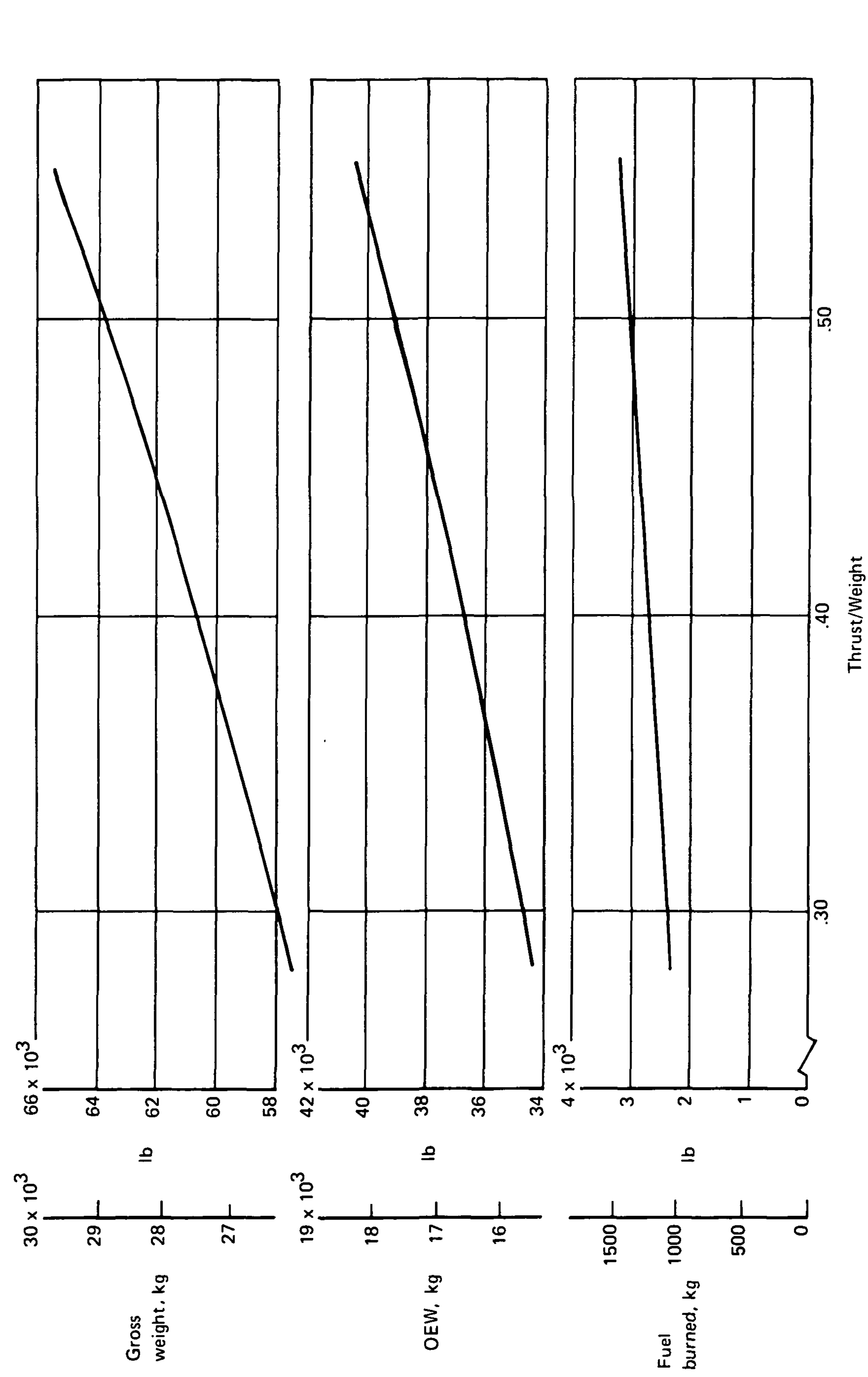


FIGURE 6-48.—SENSITIVITY TO THRUST-TO-WEIGHT RATIO—1975 AUGMENTOR WING STOL—95 PASSENGERS

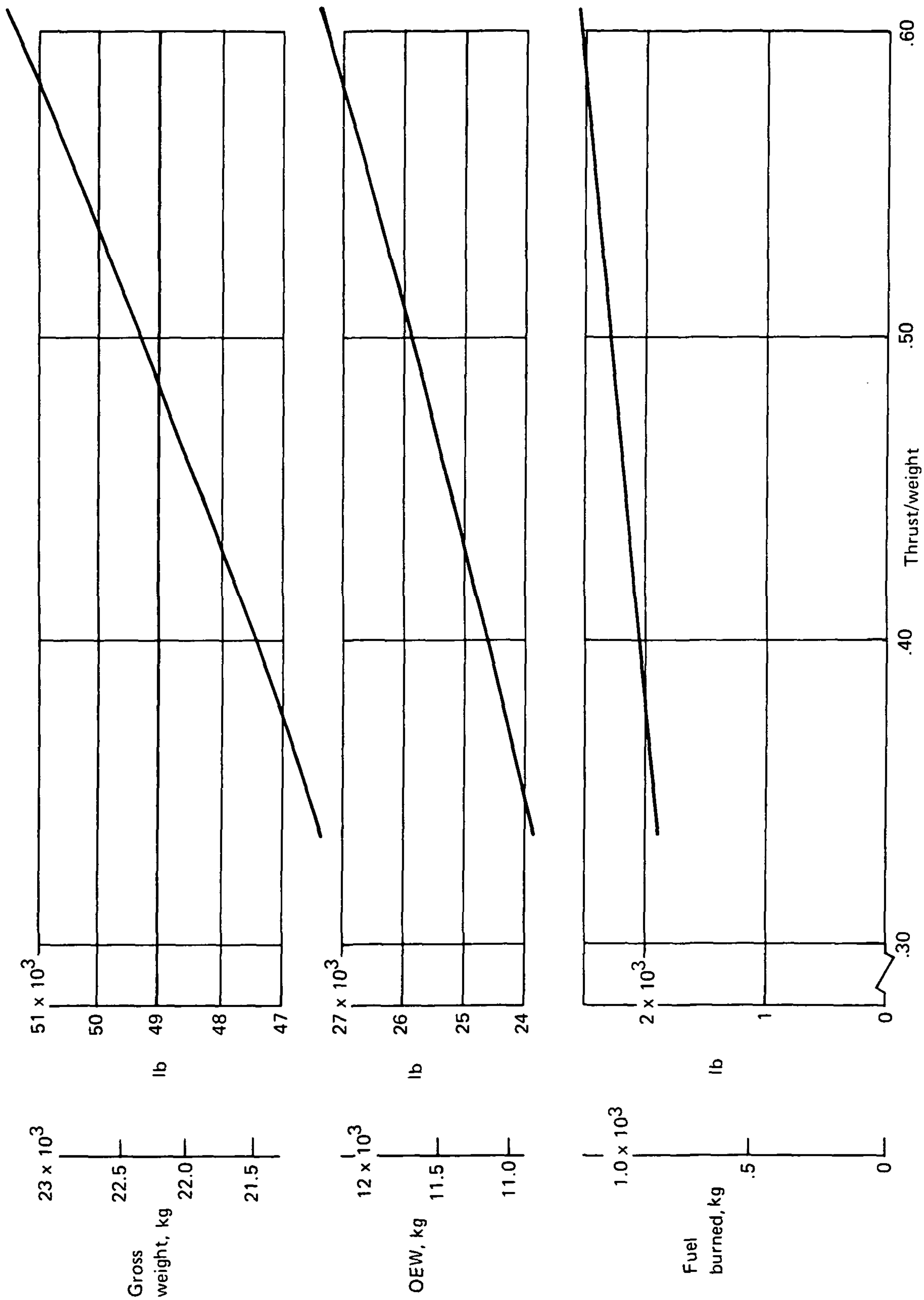


FIGURE 6-49.—SENSITIVITY TO THRUST-TO-WEIGHT RATIO—1985 AUGMENTOR WING STOL—95 PASSENGERS

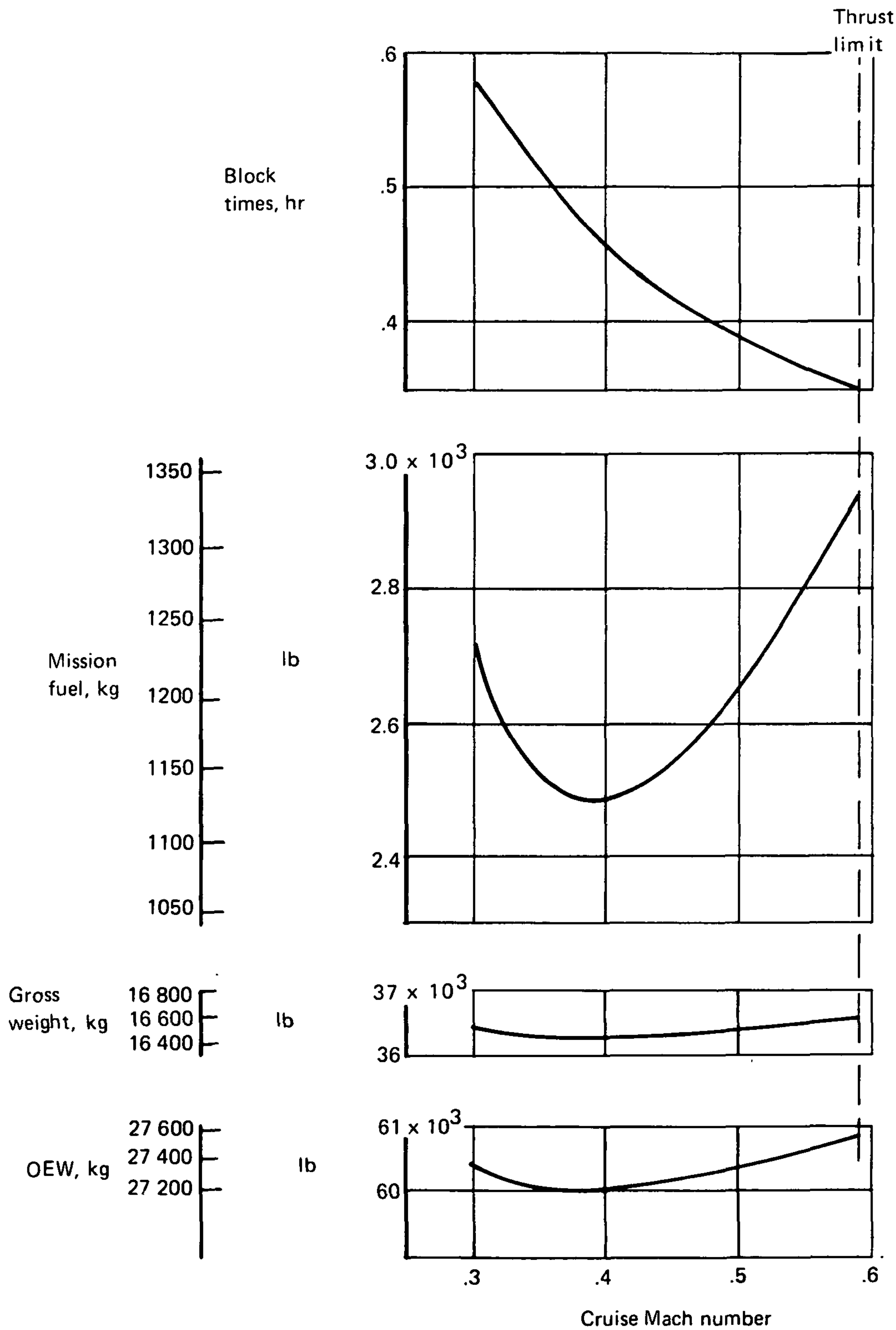


FIGURE 6-50.–SENSITIVITY TO DESIGN CRUISE MACH NUMBER–1975 AUGMENTOR WING STOL–95 PASSENGERS

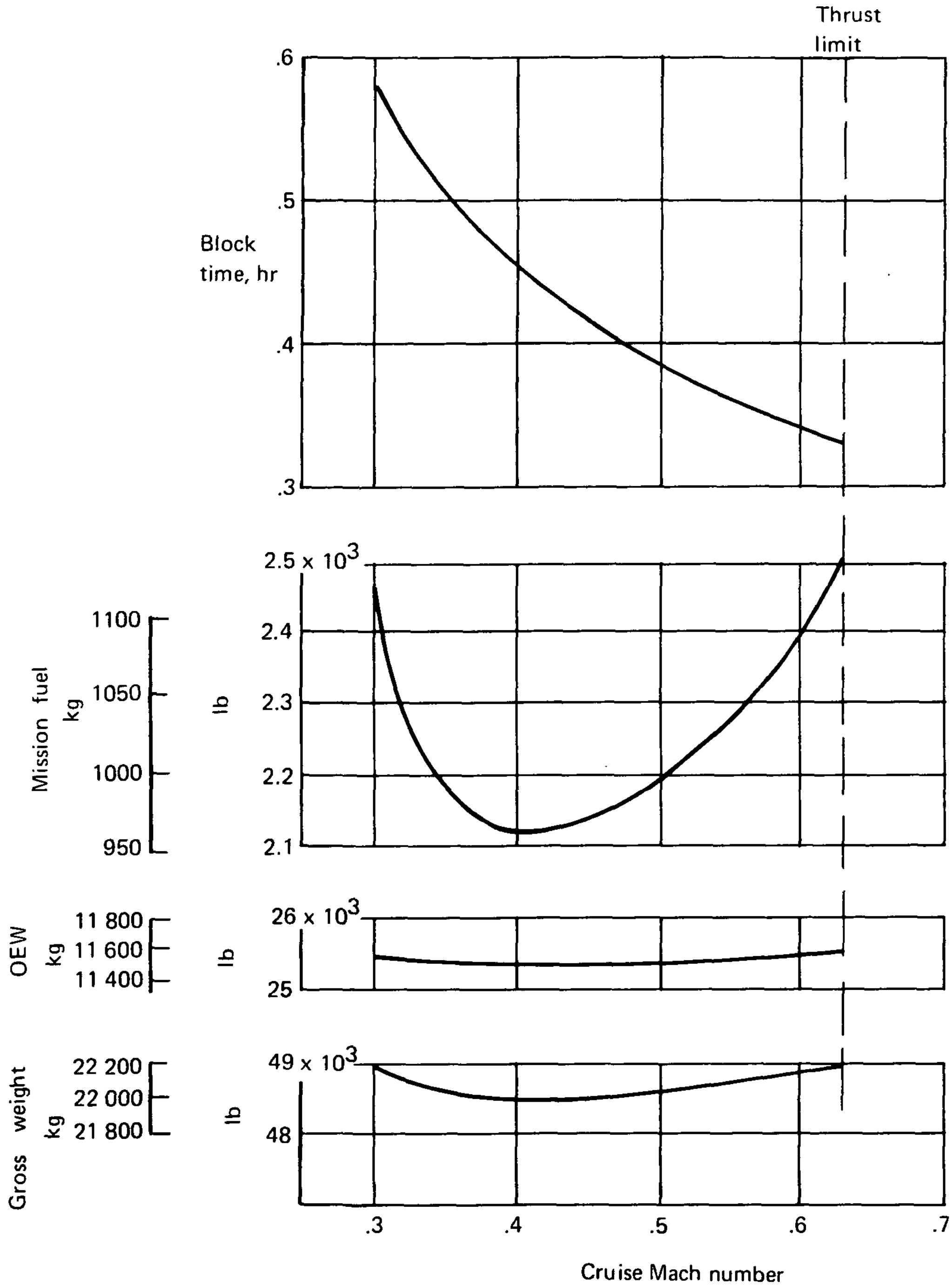


FIGURE 6-51.—SENSITIVITY TO DESIGN CRUISE MACH NUMBER—1985 AUGMENTOR WING STOL—95 PASSENGERS

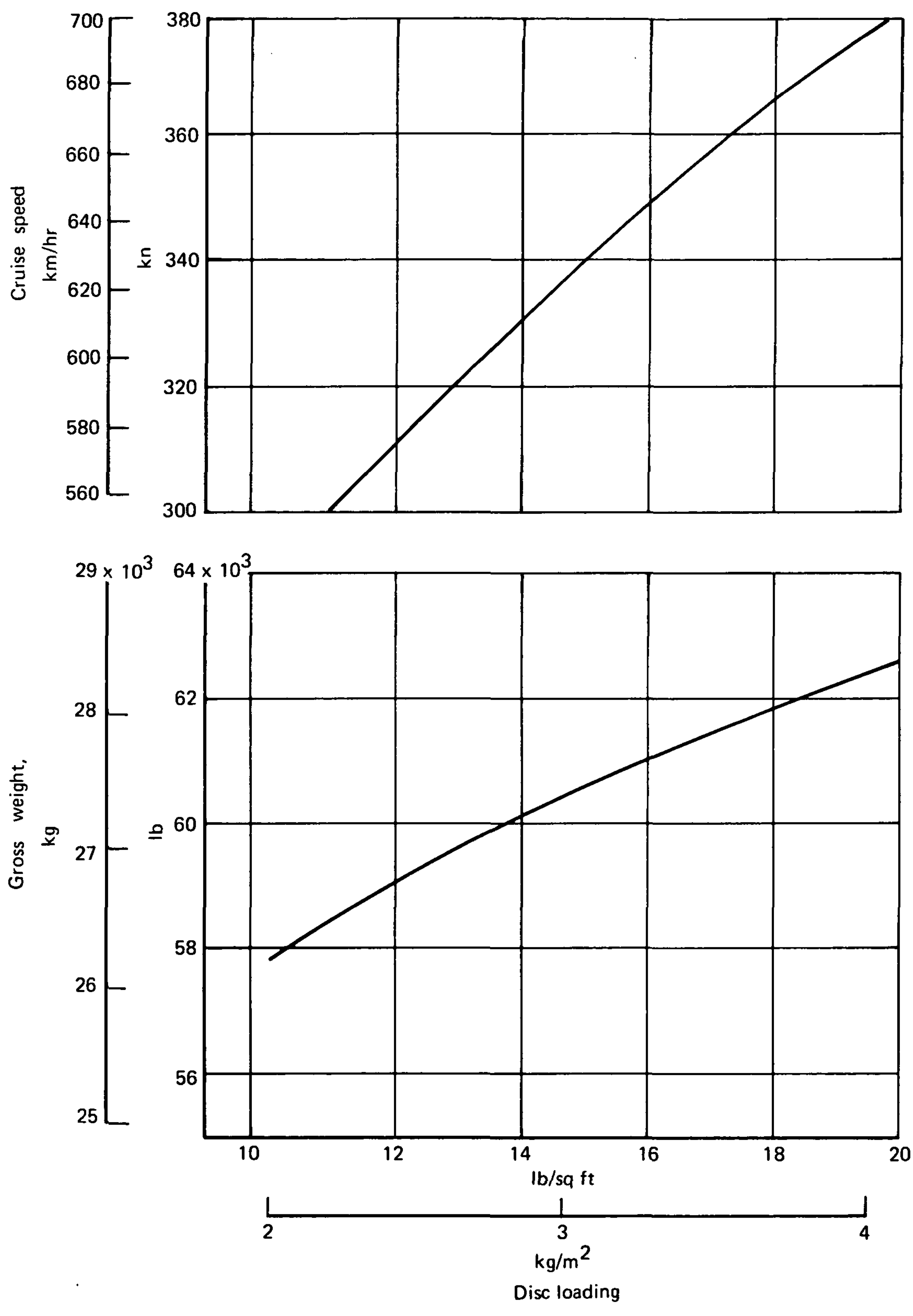


FIGURE 6-52.—DISC LOADING SENSITIVITY—1985 TILT ROTOR—100 PASSENGERS

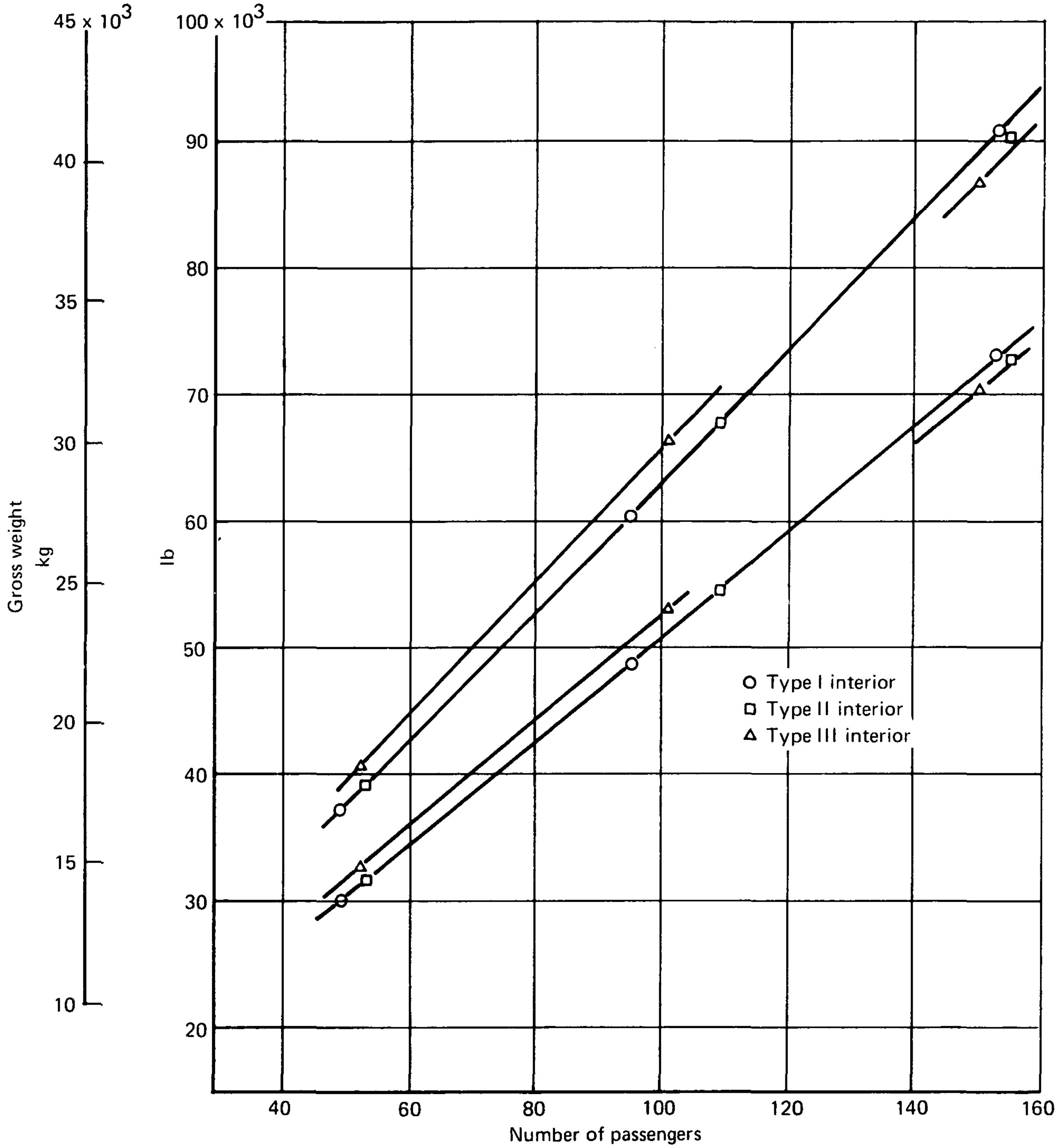


FIGURE 6-53.--AUGMENTOR WING STOL CABIN INTERIOR VARIATION

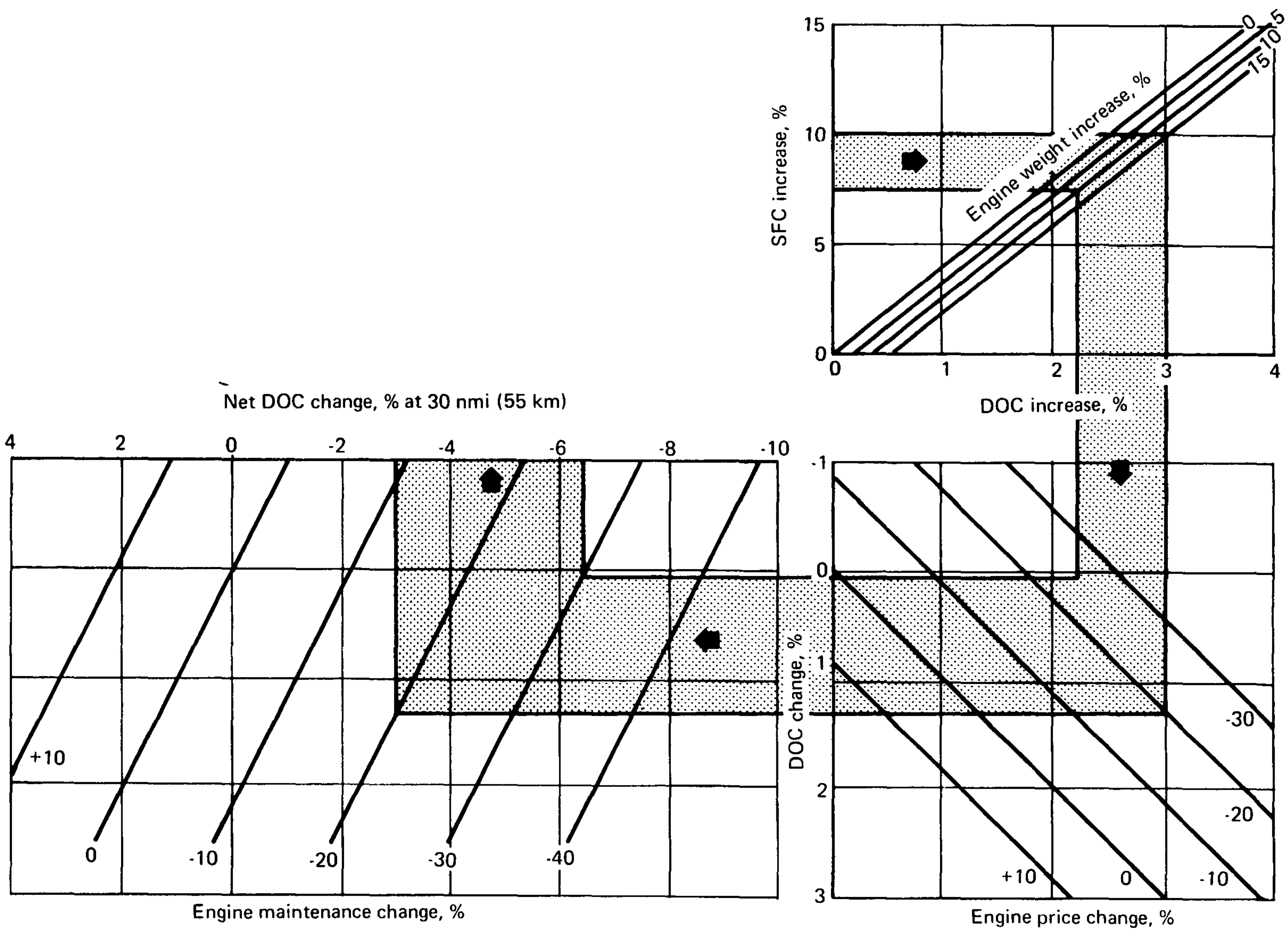


FIGURE 6-54.—LOW MAINTENANCE ENGINE SENSITIVITY, AUGMENTOR WING AIRPLANE

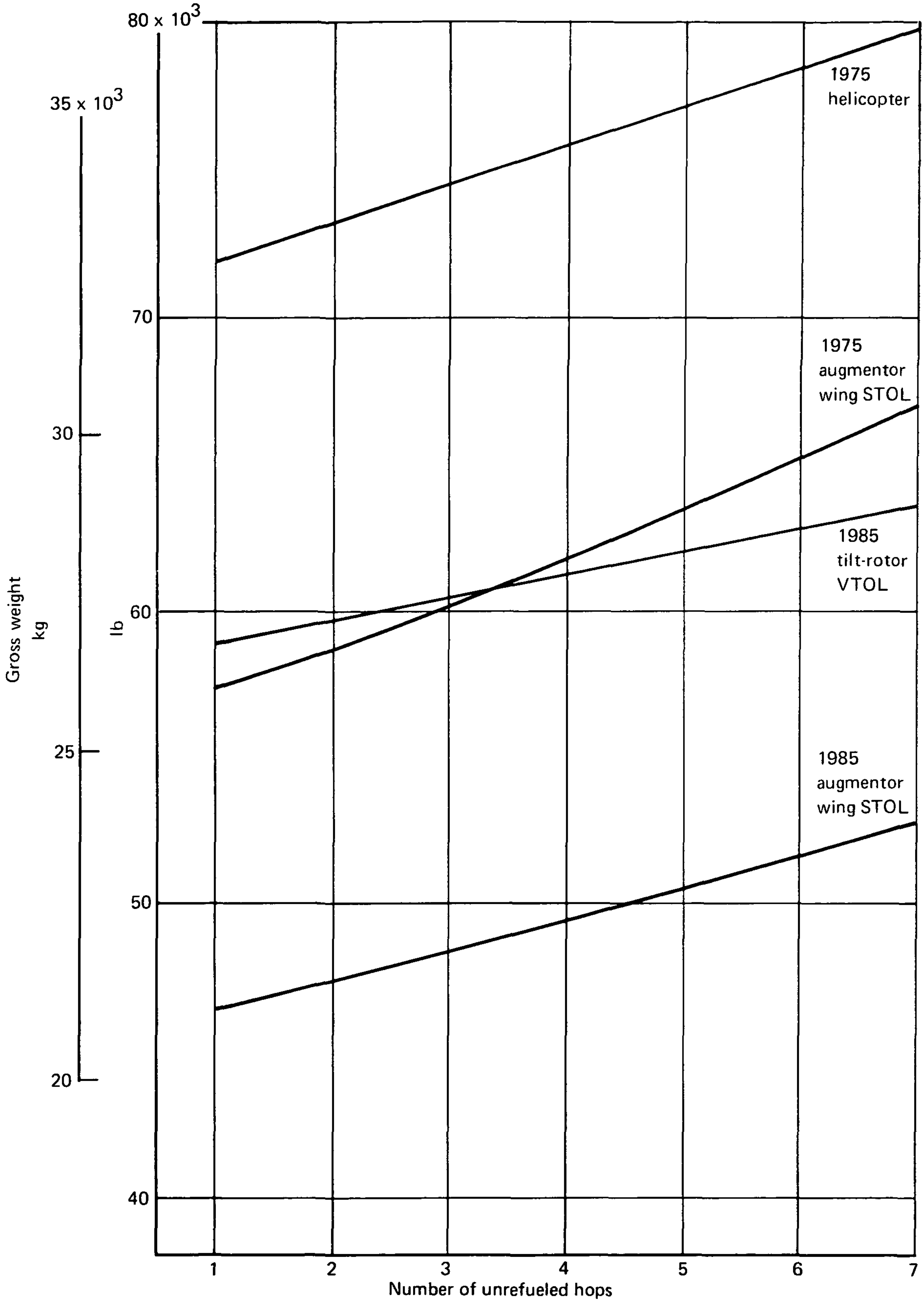


FIGURE 6-55.–SENSITIVITY TO NUMBER OF HOPS–
20-NMI HOP DISTANCE–100 PASSENGERS

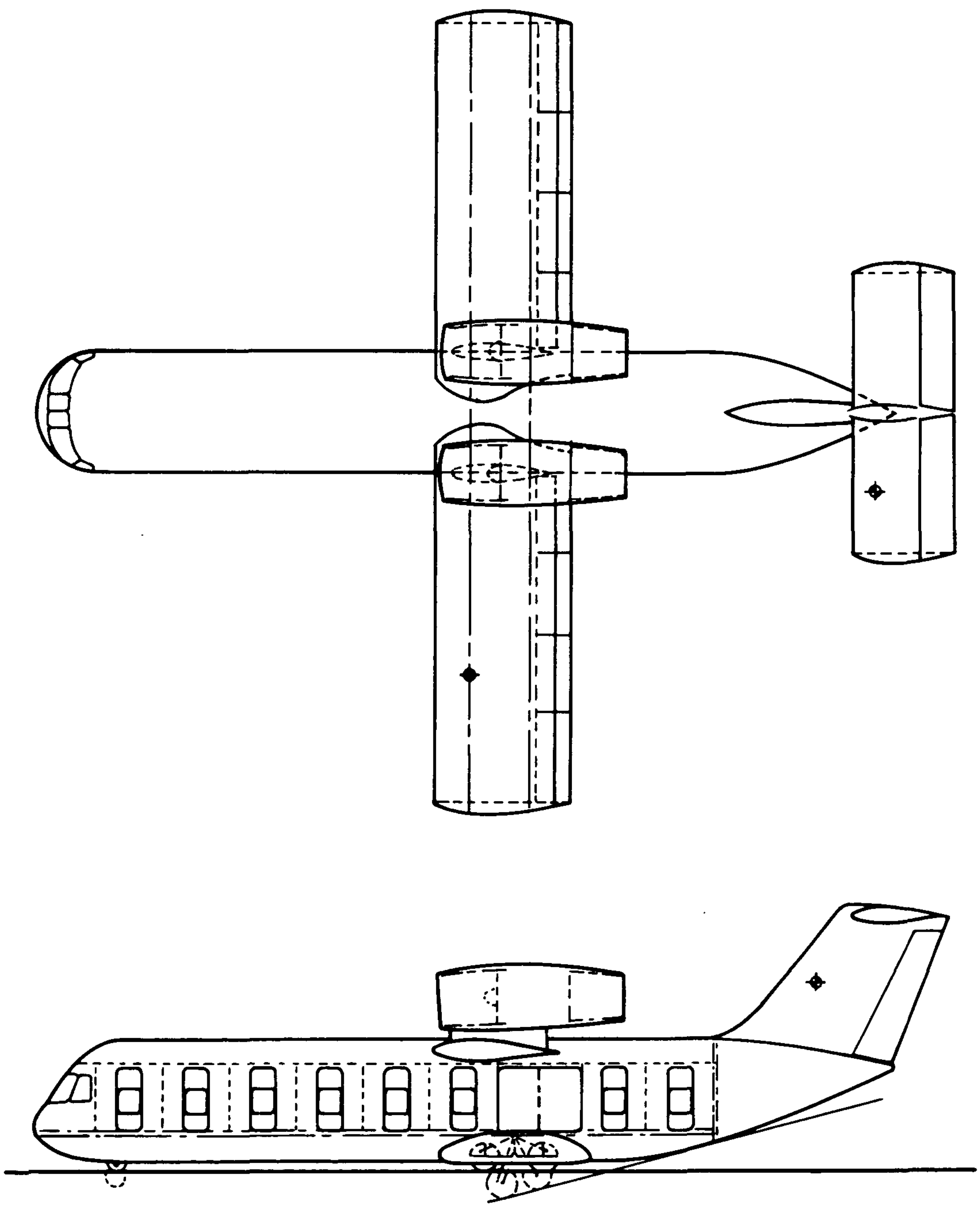


FIGURE 6-56.—1975 CONVENTIONAL STOL GENERAL ARRANGEMENT —95 PASSENGERS

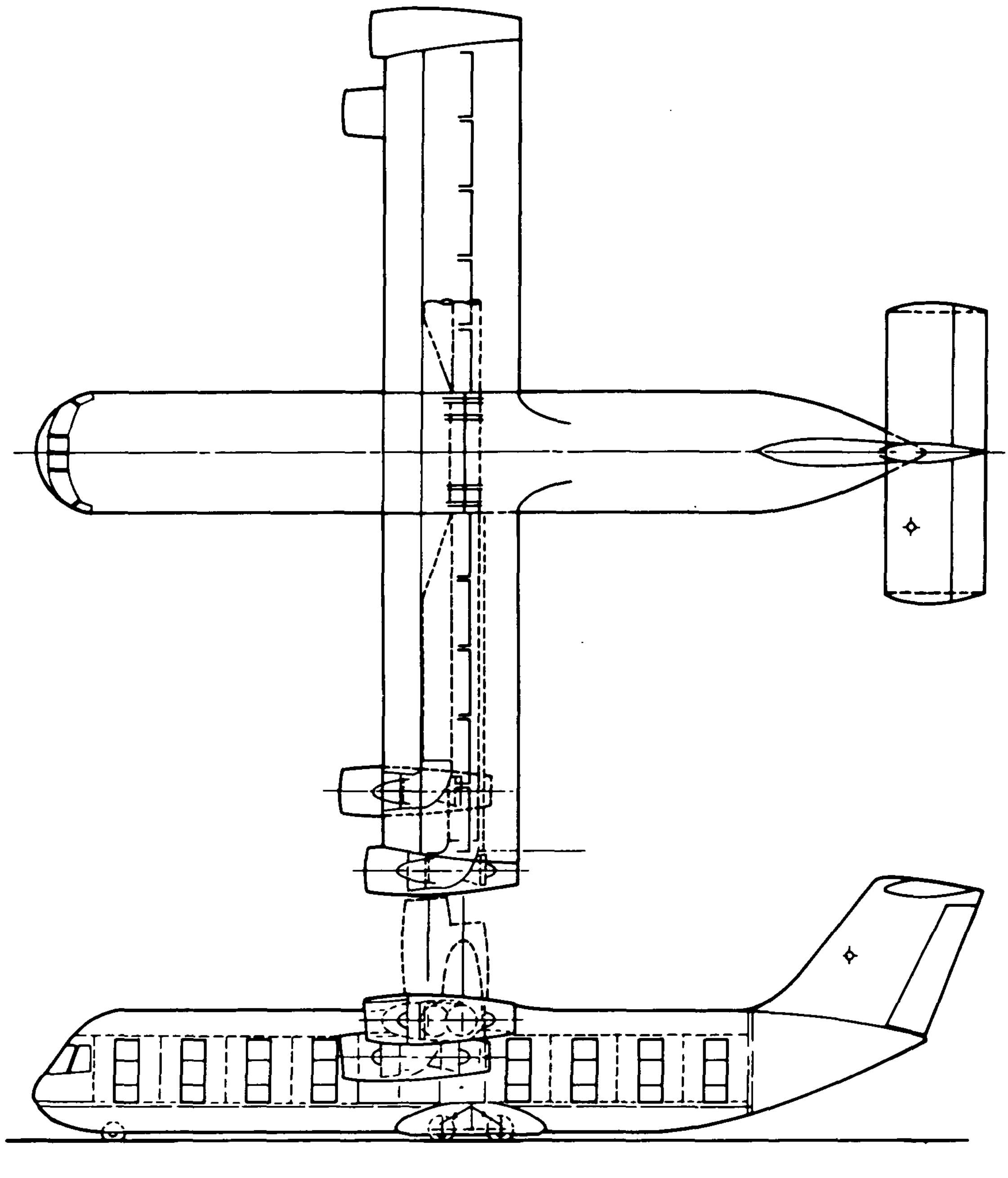


FIGURE 6-57.– 1985 EJECTOR WING VTOL GENERAL ARRANGEMENT, 95 PASSENGERS

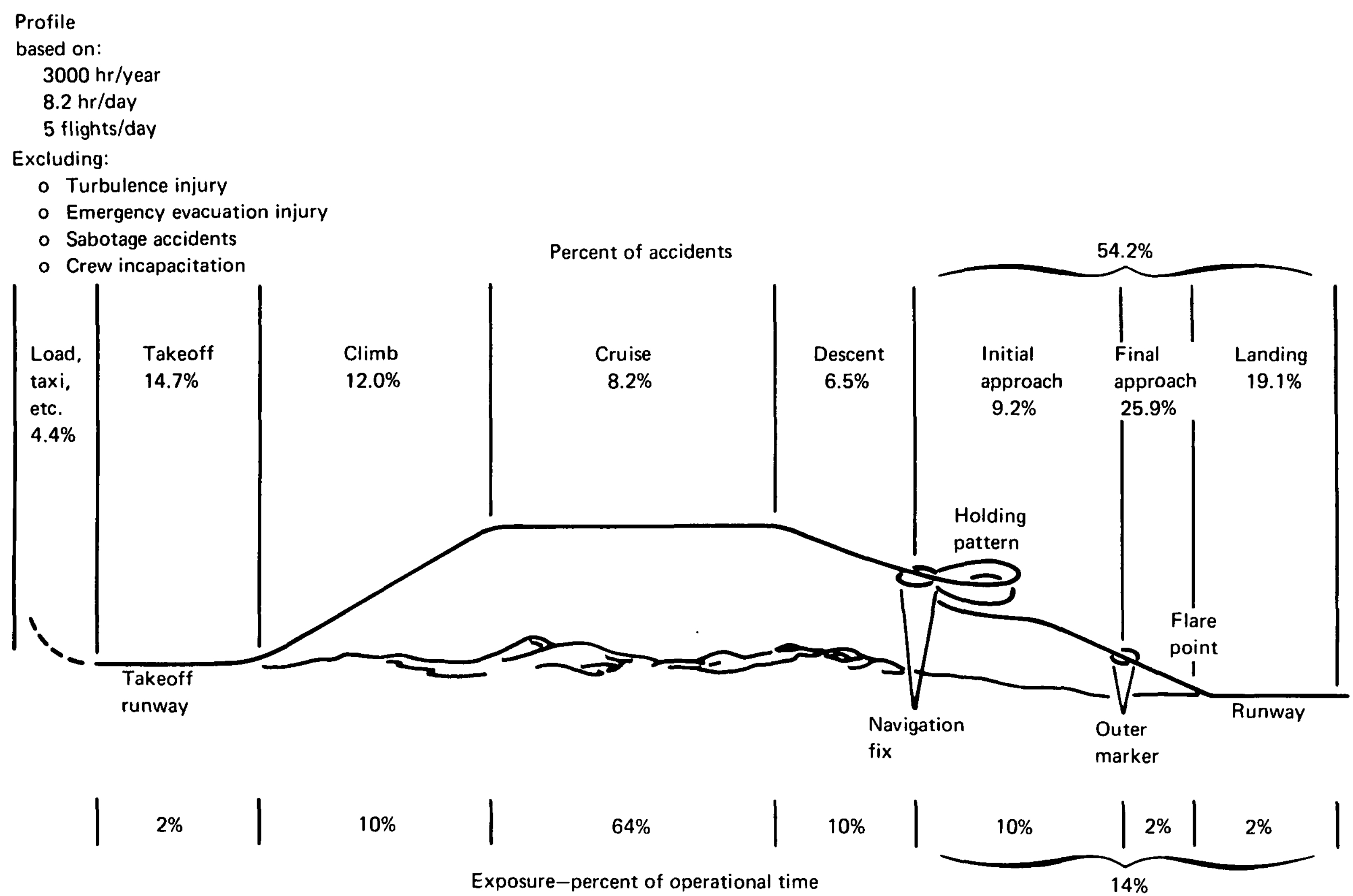


FIGURE 6-58.— ACCIDENTS FOR FREE WORLD JET FLEET—1959-1969

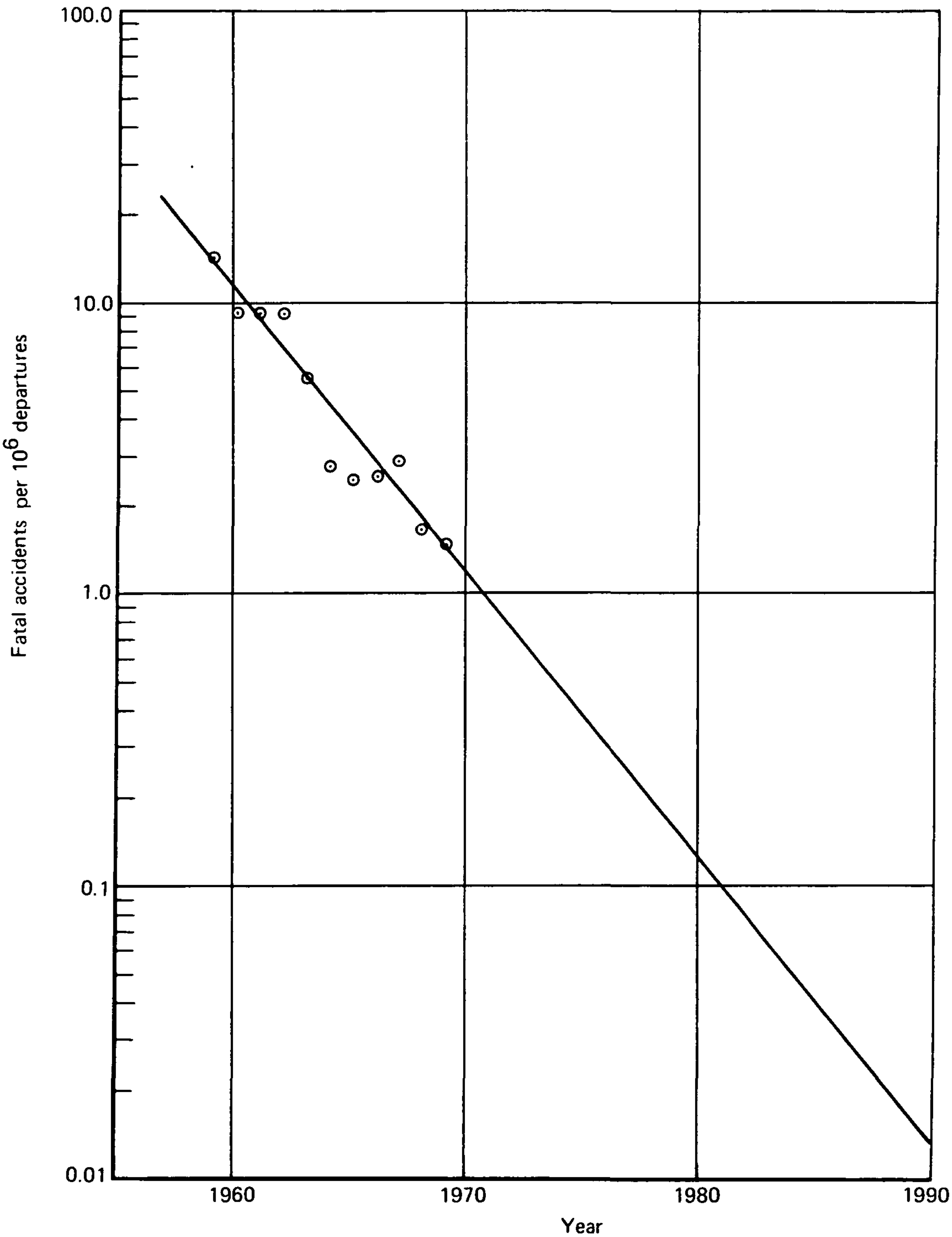


FIGURE 6-59.—U.S. JET AIR TRANSPORT FATAL ACCIDENT RATE

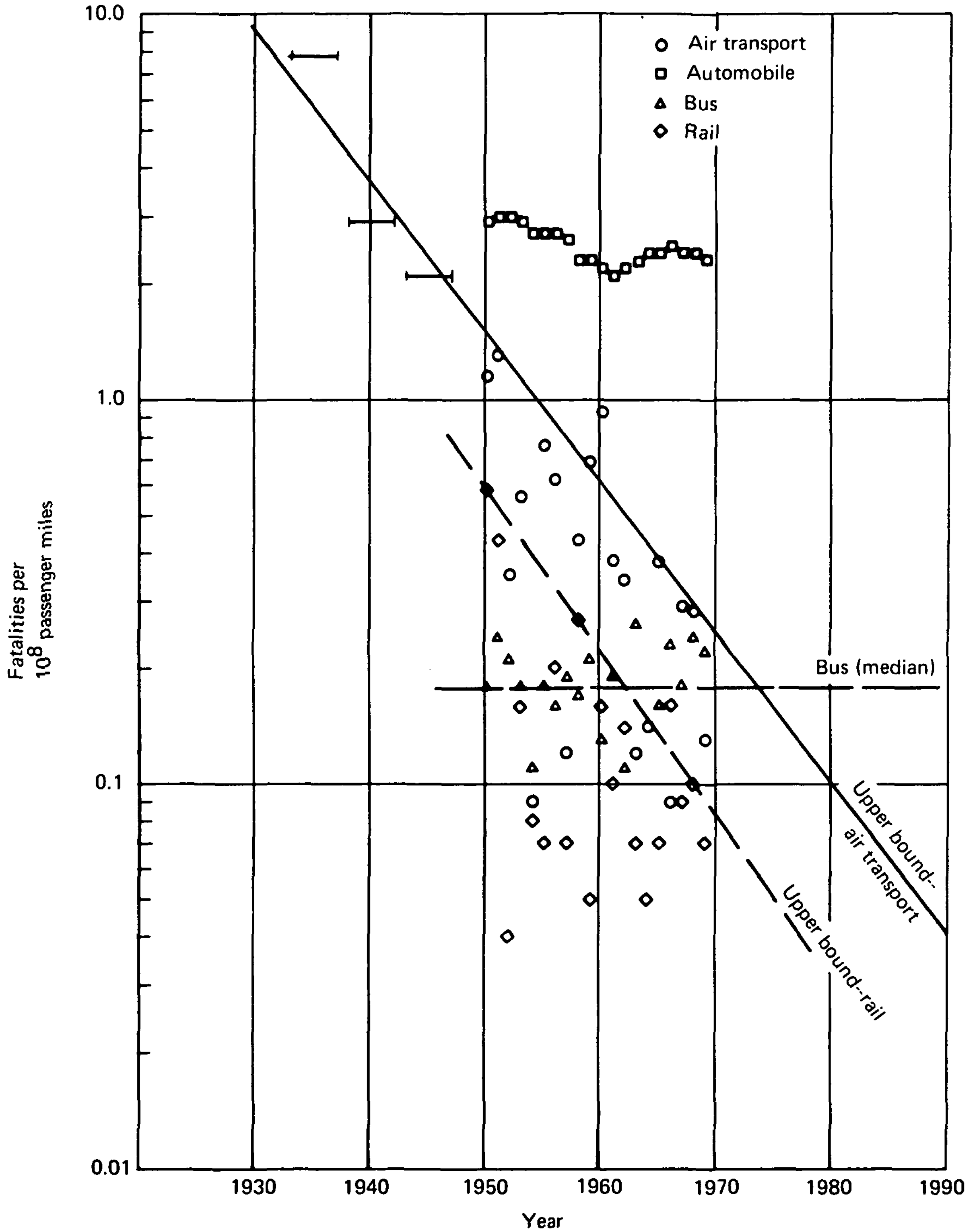


FIGURE 6-60.—U.S. ACCIDENTAL FATALITY RATE

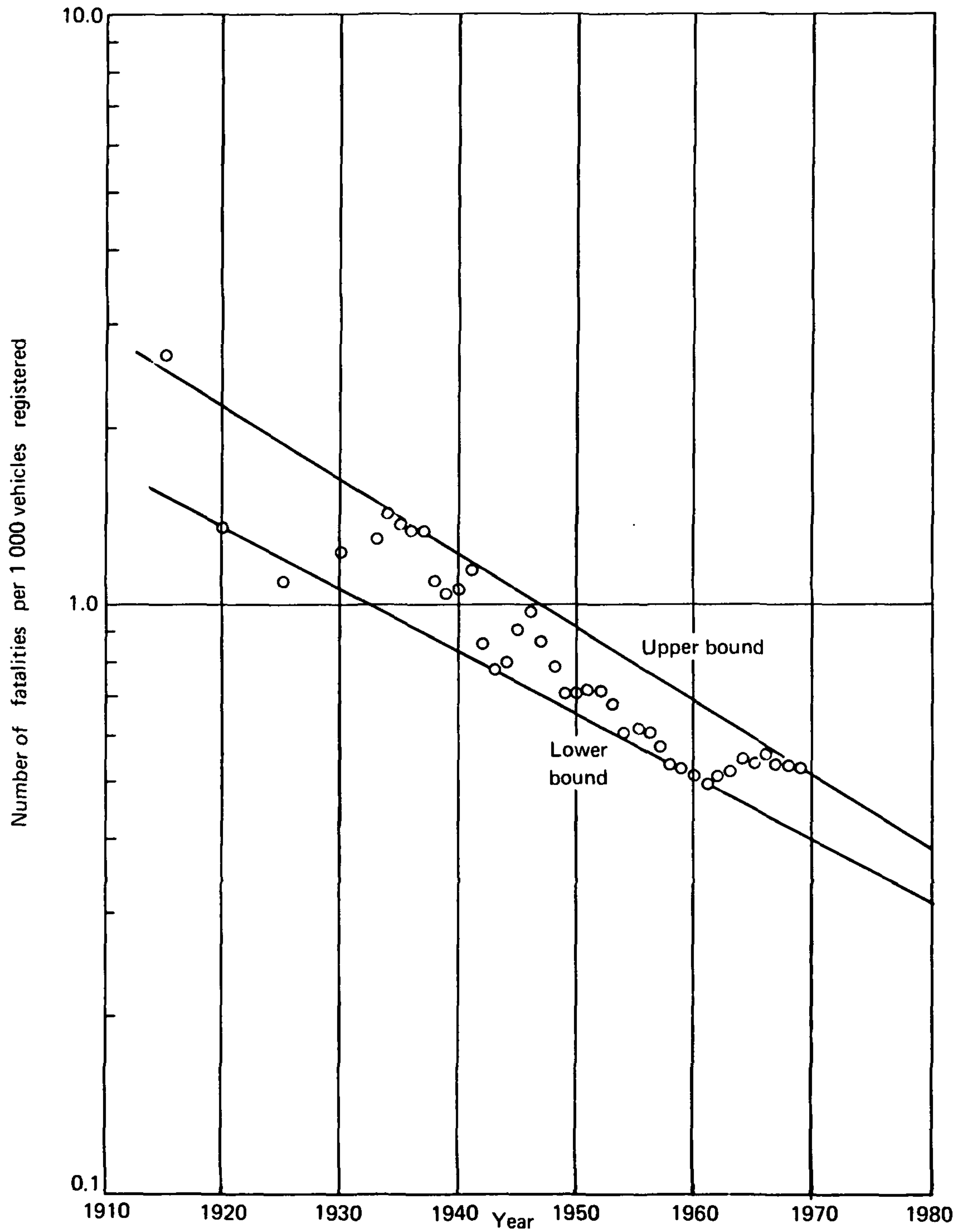


FIGURE 6-61.— MOTOR VEHICLE ACCIDENTAL FATALITY RATE

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7.0 NOISE ANALYSIS AND DATA

An important factor affecting the technical, economic, and operational characteristics of an airborne intracity rapid-transit system is noise. The vehicles must be quiet enough to be acceptable both in the center of the city and in the residential and business areas over and into which they operate. If they are not, there may be operating restrictions imposed that could seriously impair the operation economically or, indeed, prevent its operation altogether. Finally, it is very important that the system be allowed to operate at its full potential and not be limited by operating restrictions in ways that could affect system flexibility and safety. Accordingly, this section discusses criteria for judging the acceptability of noise, the noise levels that may be encountered from intraurban aircraft, and the technology required.

7.1 DESCRIPTION OF NOISE

The assessment of the impact of aircraft noise on people in an urban area certainly must take into account the noise level, the frequency of flights, the time of day (whether day or night), and the amount of ambient noise already present in the vicinity of concern. After a review of systems for describing the reaction of people to noise, the noise exposure forecast (NEF) was adopted as including the necessary factors, provided it could be modified to include the effects of ambient noise. A method has been employed for doing this, and the basic equation for NEF, adjusted for ambient noise, is

$$NEF_A = PNL_{EFFA} + \Delta PNL_{OPS} - 75 \qquad (1)$$

where PNL_{EFFA} is the effective perceived noise level calculated from a sound level spectrum corrected for ambient noise, ΔPNL_{OPS} is the correction for the number of flights per day, and 75 is an arbitrary subtrahend to yield a numerical value substantially different from numbers encountered in other systems such as sound pressure level, perceived noise level, or loudness level. It is approximately the threshold of annoyance for community noise. For several aircraft types operating on or near an airport, it is necessary to combine NEFs calculated for the several airplanes. This is done by logarithmic combination, for one runway or flightpath, by using the equation

$$NEF_j = 10 \log_{10} \sum_i 10 \log_{10}^{-1} \frac{NEF_{ij}}{10}$$

For multiple aircraft types and flightpaths,

$$NEF_{TOTAL} = 10 \log_{10} \sum_j \log_{10}^{-1} \frac{NEF_j}{10} .$$

Pairs of NEF can be combined using figure 7-1. ΔNEF_2 is the amount to be added to the larger, NEF_2.

The components of the NEF equation as well as the criteria levels are described below.

7.1.1 Ambient Noise Level

Subjective reaction to a noise source depends on the ambient noise level. One can easily comprehend this by noting that, when the ambient noise level is high enough, the noise source is masked and the listener is not then aware of it at all. Under less extreme circumstances, the effect of ambient noise is to modify the reaction that would otherwise be obtained without ambient background noise. Ordinarily, the ambient noise level is not considered in making subjective noise calculations. It is possible to include the effects of ambient noise with the use of figure 7-2. One-third-octave or octave-band sound levels of the stimulus have subtracted from them the amount read on the ordinate for a given difference between the stimulus sound level and the ambient sound level read on the abscissa. This corrected sound level spectrum is used to calculate perceived noise level. An approximate and more direct method of making this calculation is given in the next section. As an aid to estimating ambient community noise levels, tables 7-1 and 7-2 are included. Table 7-1 is a tabulation of sound levels measured at selected locations in the San Francisco area by a NASA design study team working at Stanford University (ref. 20). Table 7-2 lists urban noise levels tabulated for the Federal Aviation Agency (refs. 21 and 22). (An increase of 1 dB per year since 1964 has been assumed.)

7.1.2 Effective Perceived Noise Level

Effective perceived noise level is a measure of subjective reaction to sound, which includes corrections for time duration and discrete frequency spectral content.

The standard procedure for calculating effective perceived noise level is described in detail in reference 4 (FAR 36).

To facilitate the calculation of perceived noise level taking into account the effect of ambient noise, figure 7-3 has been included. The use of this figure in effect modifies equation (1) to

$$NEF_A = PNL_{EFF} + \Delta PNL_A + \Delta PNL_{OPS} - 75. \tag{2}$$

The first term is now the standard effective perceived noise level. The second term, ΔPNL_A, which is the ambient noise adjustment, is read from figure 7-3. It is well to remember that this is an approximate method and may not yield consistent results when it is applied to aircraft having widely different sound level spectra.

7.1.3 Frequency of Flights

Another important parameter in calculating noise exposure forecast is the number of operations (takeoffs or landings) at a given location. The next-to-last term in either equation, ΔPNL_{OPS}, introduces the frequency of operations into the calculation. Figure 7-4 gives the value of this term for a range of flight frequencies. It is well to note that the effect of operation frequency is more pronounced at night than it is in daytime. A given number

of operations at night adds 12 dB more to the NEF than does the same number of operations during daytime. Here, day is defined as 0700 to 2200 and night 2200 to 0700 on the 24-hr clock.

7.1.4 Criteria

It is assumed that noise criteria for an intraurban system should strive for acceptability rather than test endurance of the people it affects. Accordingly, speech interference as well as other annoyance criteria were considered. Robinson's criterion of 85 PNdB (ref. 5), which he considers the maximum allowable in a quiet residential area, corresponds approximately to a preferred speech interference level (PSIL) of 65 dB, which will permit uninterrupted speech communication over distances of 2 to 8 ft. This is consistent with communication requirements for domestic recreation activities and other pursuits in which accompanying conversation is common and desirable. The corresponding noise exposure forecast, NEF, is, therefore, established as 10 for residential areas and 15 for industrial areas.

7.2 AIRCRAFT NOISE LEVELS

Noise levels are given for three different classifications of aircraft. These noise levels do not contain any adjustment for the effect of ambient noise. These classifications are: augmentor wing, helicopter, and tilt rotor.

These noise levels are given as a basis for calculating NEF for specific locations and for estimated traffic densities. Takeoff and landing profiles assume a 35-ft (10.7 m) obstacle at the end of the runway and at threshold, respectively.

7.2.1 Augmentor Wing

There are two versions of this airplane, one with 1975 technology and the other 1985 technology. The main differences that affect noise are the changes in engine performance parameters and in the aerodynamic configuration of the airplane as these affect the engine thrust requirements for takeoff and landing. Takeoff and landing profiles are given in figures 7-5 and 7-6. The takeoff profile assumes that the airplane will achieve an altitude of 35 ft (10.7 m) at 1500 ft (457 m) from brake release and climb at an angle of 14°. The landing profile is based on a 6° glide slope. Takeoff and landing noise contours for the 1975 airplane are given in figures 7-7 and 7-8. The takeoff noise contour for the 1985 airplane is given in figure 7-9.

7.2.2 Helicopter

Rotor rotational and vortex noise were calculated by the methods of Lowson and Ollerhead (ref. 23) and Schlegel et al. (ref. 24). An empirical correction of 5 dB was added to the levels predicted by Schlegel's method to give agreement with test data better than with uncorrected predictions. Far-field extrapolation included allowance for spherical spreading and atmospheric absorption. No allowance for ground attenuation was included.

The flight profile was as shown in figure 7-10. The approach profile would be similar to that for takeoff; however, reduced thrust at the midpoint during descent reduces the noise levels somewhat, thus contracting the EPNdB contours at this point only. The rotor was assumed to be the only significant noise source; the power plant installation will provide adequate inlet treatment. For this study, the jet velocities of the engines are assumed to be sufficiently low that jet noise does not contribute to the noise signature. No tone correction has been included in the EPNL contours; however, an increment for time duration has been included, and this significantly adds to the uncorrected PNL, particulary at the point of brake release and during climb. Effective perceived noise level contours for 100- and 150-passenger helicopters for 1975 are shown in figures 7-11 and 7-12.

7.2.3 Tilt Rotor

The same considerations as in the previous section apply to this airplane. EPNL contours for a 1985 airplane are shown in figures 7-13 and 7-14.

7.3 EN ROUTE NOISE

It does not appear that noise under the cruise flightpath will be a problem. Two examples will illustrate this conclusion. For the 1975 augmentor wing airplane at a typical cruise speed of Mach 0.4, jet noise will be about 10 PNdB less than at takeoff speed for which the takeoff noise level contours (fig. 7-9) were calculated. When the airplane has a cruise altitude of 2000 ft (610 m), the effective perceived noise level on the ground will be 75 EPNdB. Assuming the ambient noise level to be 60 PNdB, the ambient noise level correction will be -15 PNdB (fig. 7-3). A further assumption of 630 operations per day will add 15 PNdB (fig. 7-4). Using equation (2) and the above assumptions, the ambient noise-corrected noise exposure factor (NEF_A) can be calculated

$$\begin{aligned} NEF_A &= PNL_{EFF} + \Delta PNL_A + \Delta PNL_{OPS} - 75 \\ &= 75 - 15 + 15 - 75 \\ &= 0 \end{aligned}$$

which is well below the NEF criteria in section 7.1.4. With higher ambient noise levels and lower operational densities, the NEF will be even less. Another example, at a cruise altitude of 3000 ft (915 m), an ambient noise level of 60 PNdB and 200 operations per day, gives the following result:

$$\begin{aligned} NEF_A &= 70 - 19 + 10 - 75 \\ &= -14 \end{aligned}$$

again well below the criteria. These two examples show that, when the airplane is cruising at Mach 0.4 or more between 2000 and 3000 ft (610 and 915 m) altitude, noise on the ground should not be a problem.

TABLE 7-1.–SOUND LEVELS MEASURED AT SELECTED LOCATIONS IN SAN FRANCISCO[a]

Location	Octave band center frequency, Hz									PNdB
	31.5	62.5	125	350	500	1000	2000	4000	8000	
	dB									
Bayshore (trucks) freeway	80	90	92	89	81	80	80	75	68	101
Bayshore (cars)	71	81	84	80	74	73	72	68	64	95
Downtown	80	84	86	80	75	74	68	60	50	91
Union Square	73	77	76	73	68	67	64	60	59	88
Hayward Air Terminal	94	92	91	90	85	75	64	50	–	98
Oakland Airport	90	85	84	80	71	69	64	58	51	91
Freemont	77	82	80	71	69	63	57	51	–	85
Pier One	70	70	68	66	65	64	63	54	49	84
Stanford Shopping Center	65	76	70	65	60	57	52	–	–	82
Mission and Jackson	82	78	74	68	64	56	50	–	–	80
Oakland-Piedmont	69	71	71	61	58	54	49	–	–	75
Berkley Pier	74	76	70	65	62	60	57	–	–	73
Palo Alto Golf Course	64	65	61	54	50	50	50	–	–	70

[a]Reference 20.

TABLE 7-2.—NOISE LEVELS FOR DIFFERENT TYPES OF LOCATIONS[a,b]

Location	Noise level, PNdB
Quiet suburban area (night)	45 to 55
Urban residential area (daytime)	55 to 65
Commercial area (light traffic)	60 to 70
Industrial area	60 to 80
Downtown commercial area	65 to 85

[a] Basic source is reference 20.
[b] Add one dB/yr since 1964 (ref. 21).

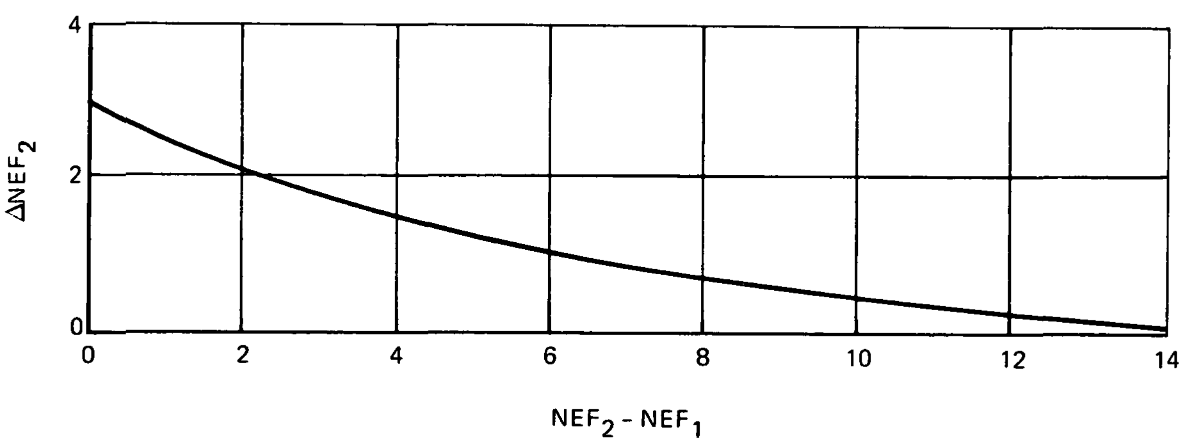

FIGURE 7-1.—NOISE EXPOSURE FORECAST ADDITION CHART

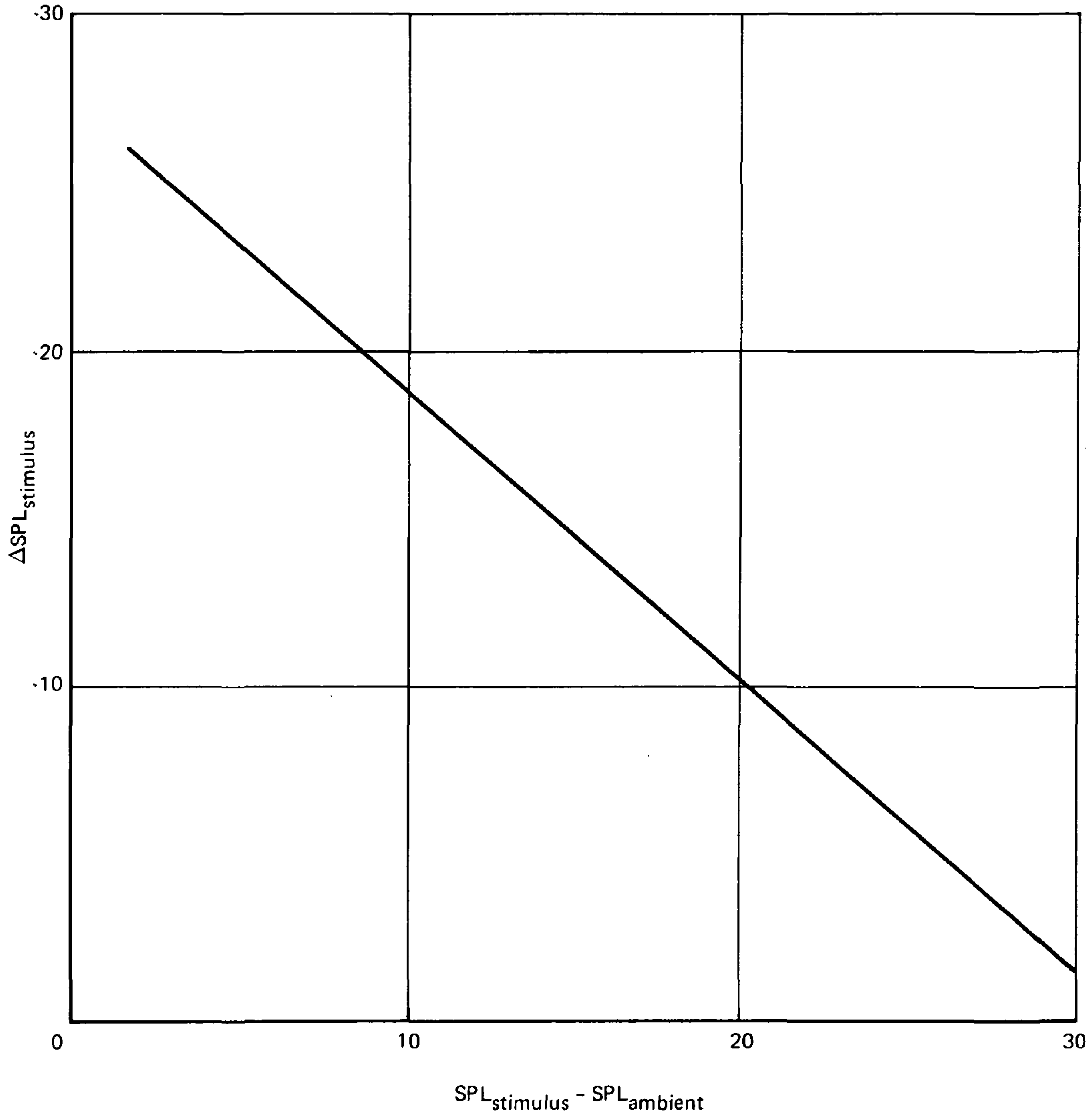

FIGURE 7-2.–AMBIENT NOISE–STIMULUS SPL CORRECTION

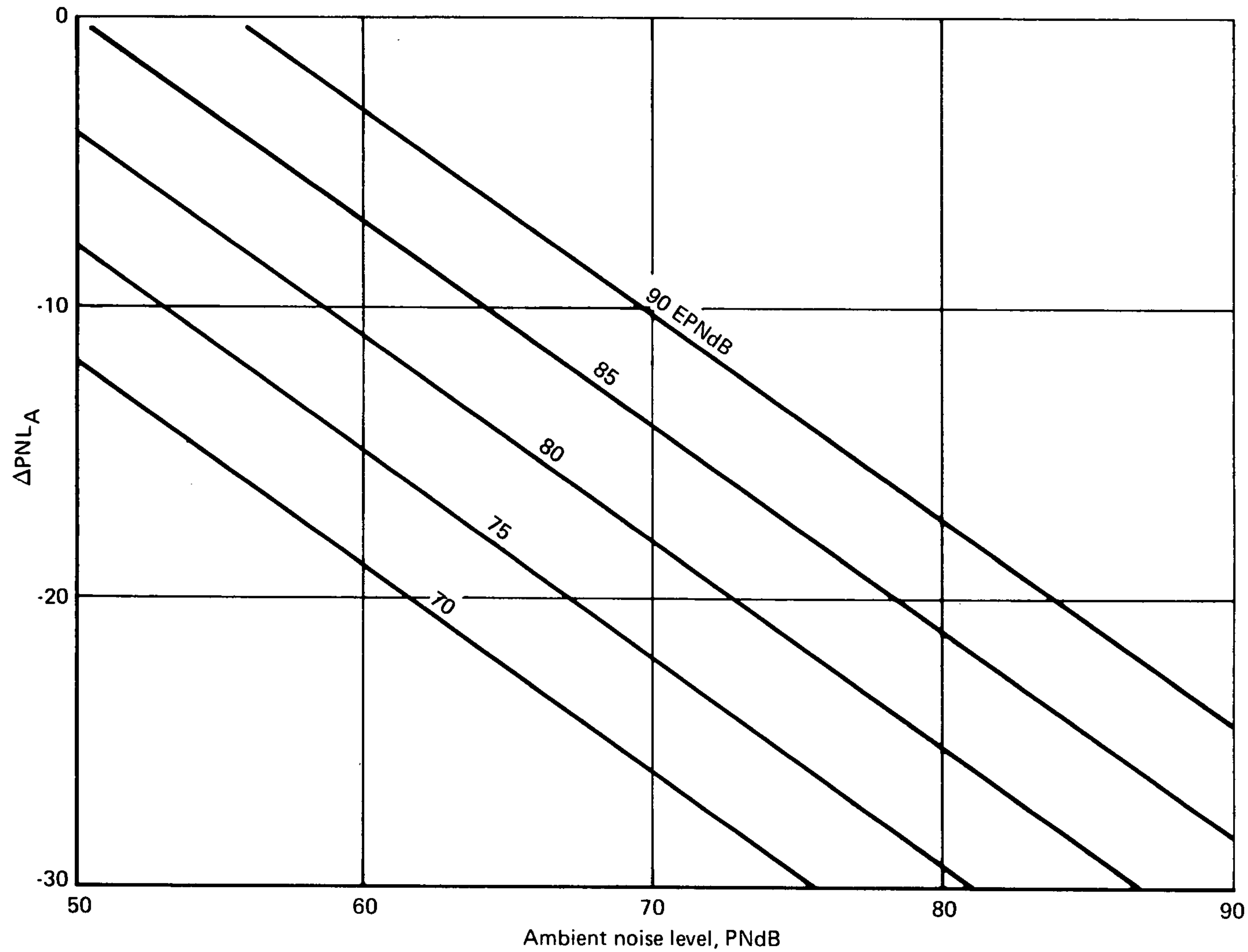

FIGURE 7-3.—AMBIENT NOISE LEVEL—NEF CORRECTION

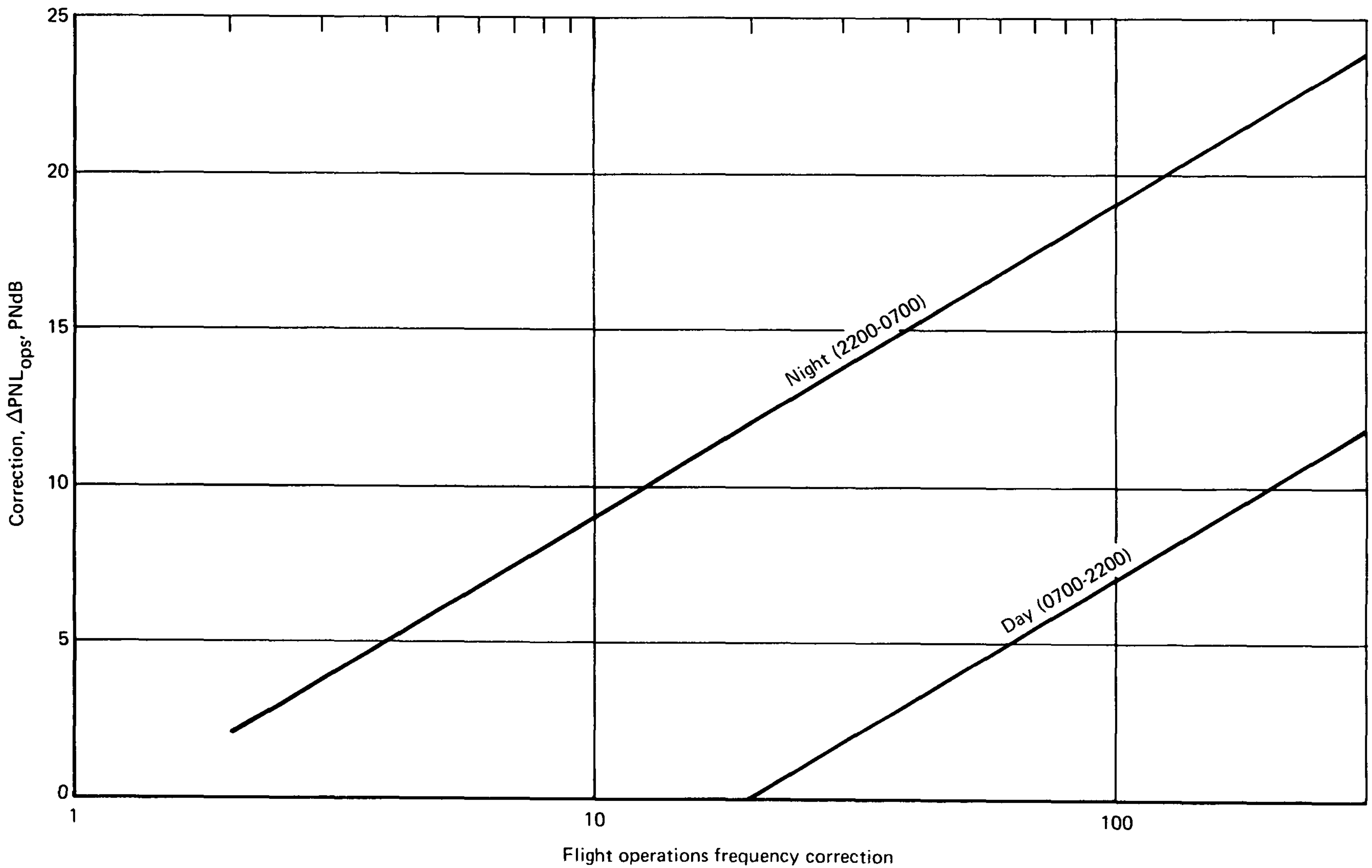

FIGURE 7-4.—NUMBER OF OPERATIONS (24 HOURS) X FRACTIONAL RUNWAY USE

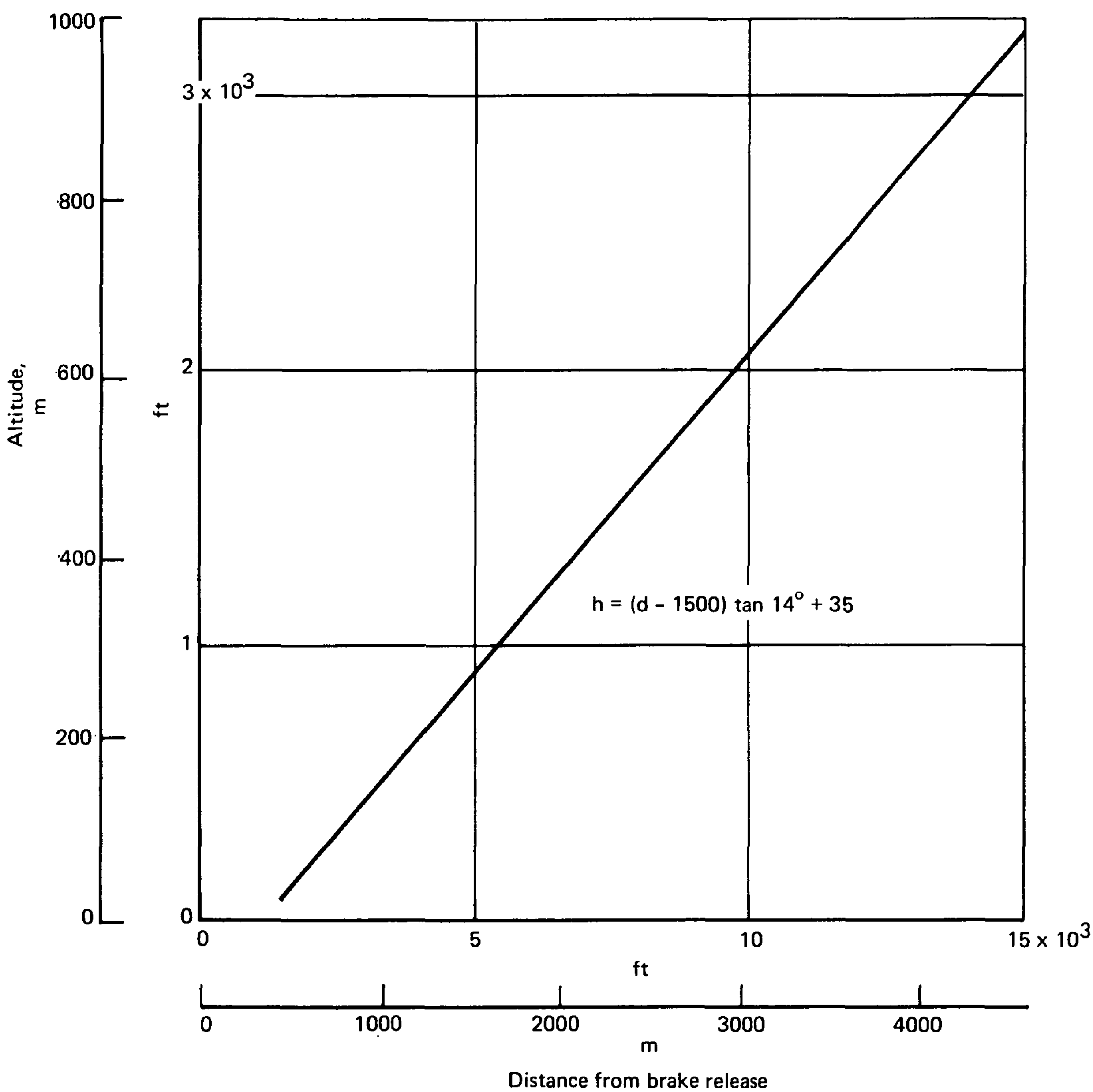

FIGURE 7-5.—TAKEOFF PROFILE

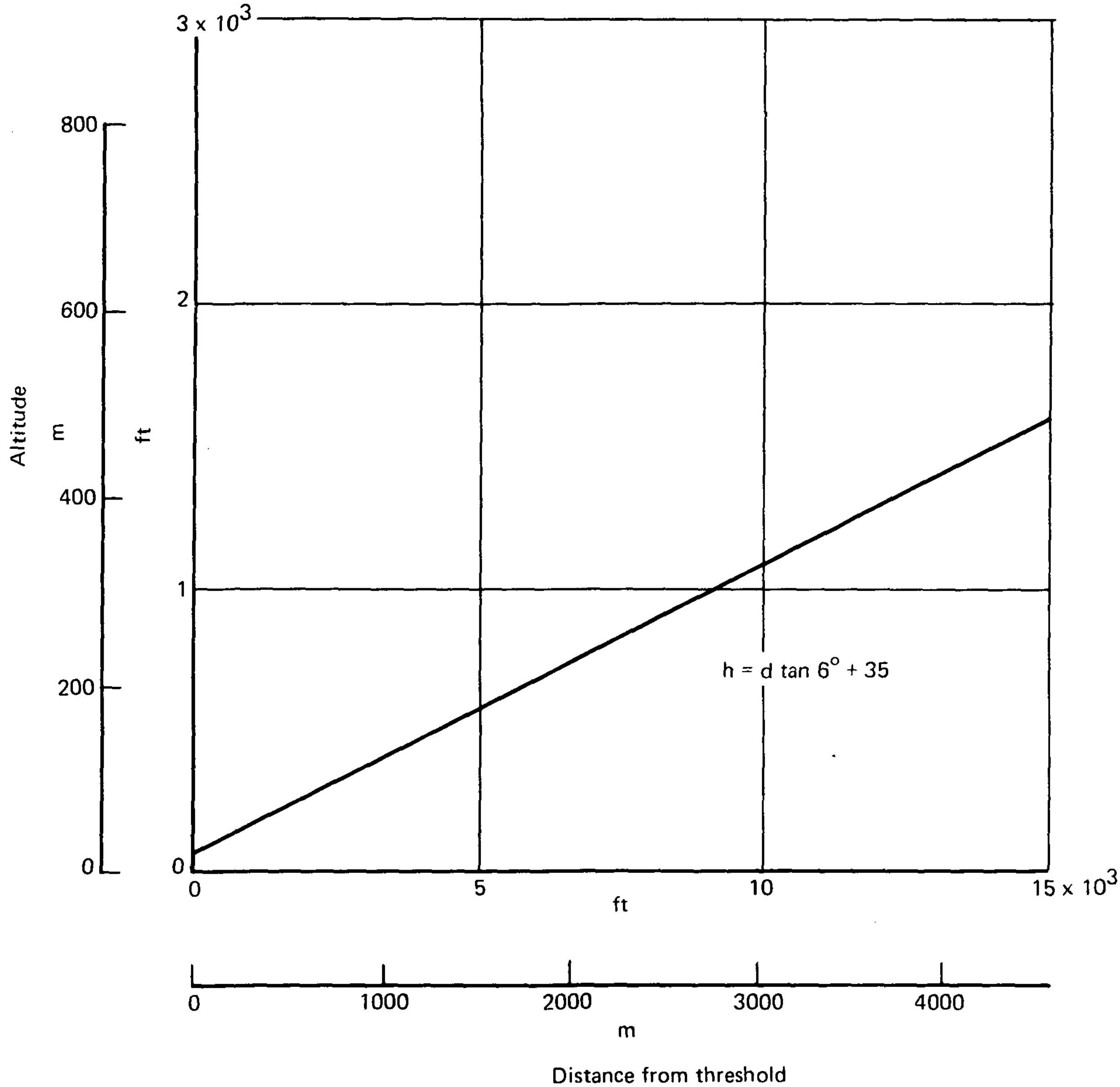

FIGURE 7-6.–LANDING PROFILE

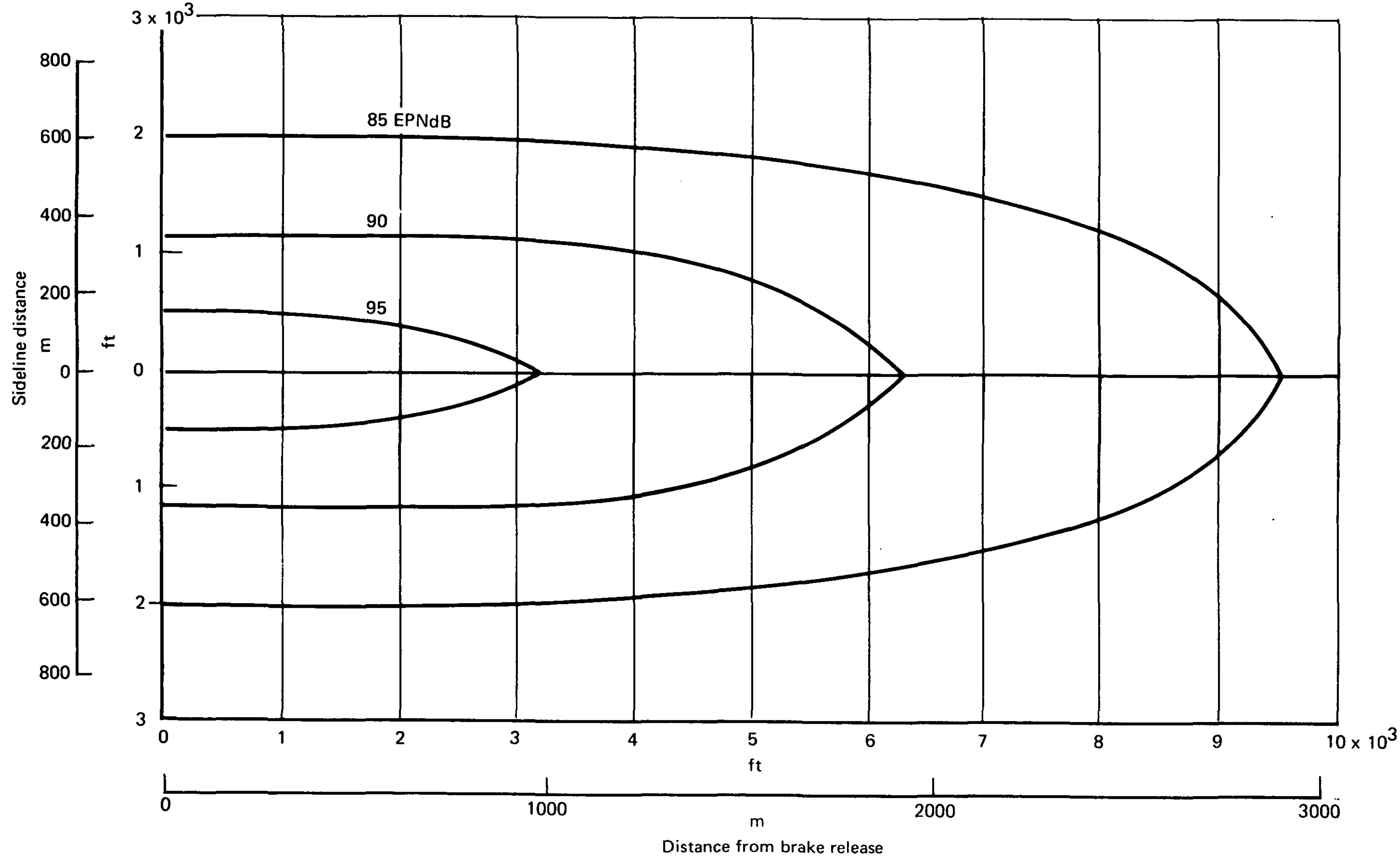

FIGURE 7-7.—TAKEOFF NOISE CONTOUR—1975 AUGMENTOR WING STOL

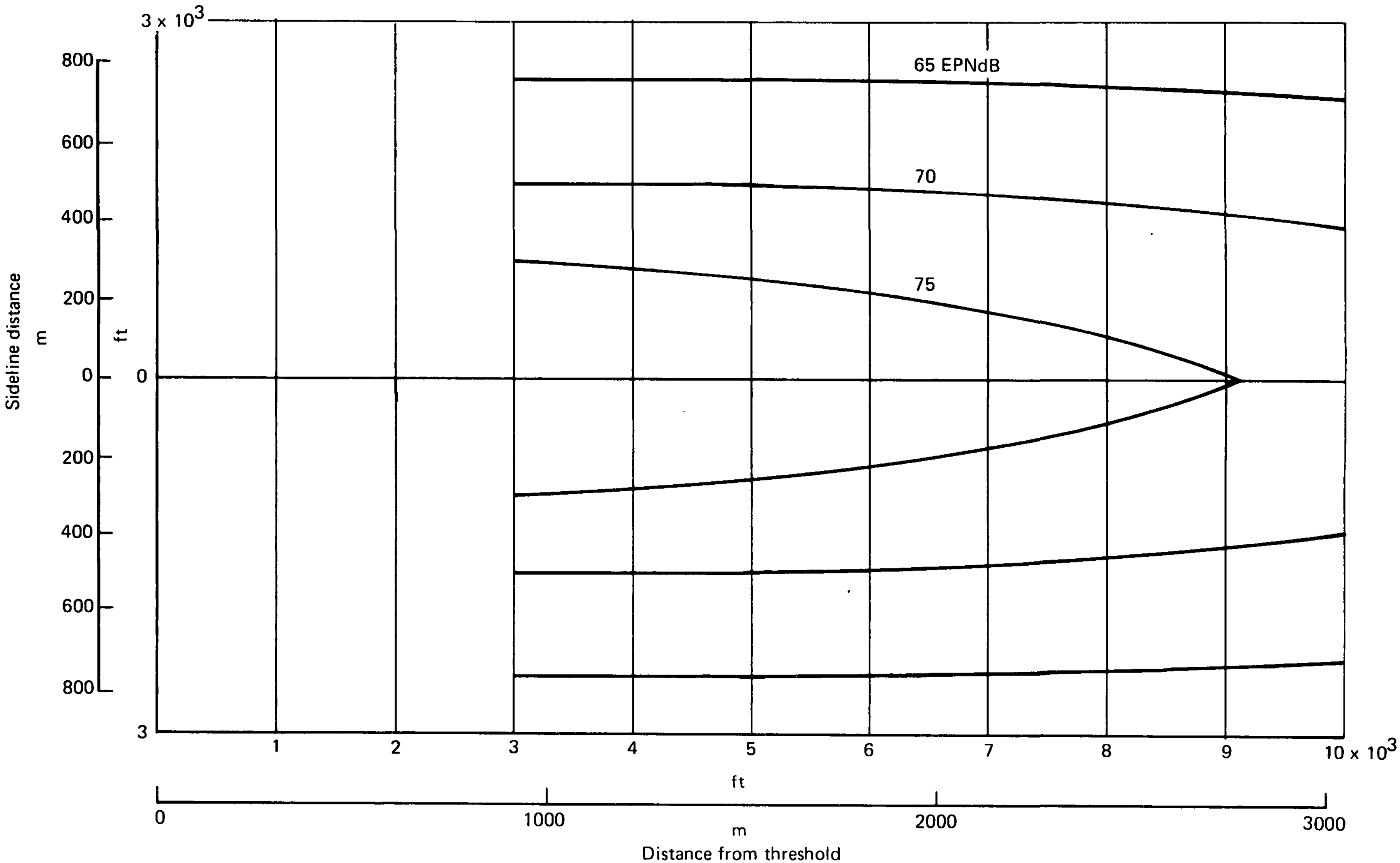

FIGURE 7-8.—LANDING NOISE CONTOUR—1975 AUGMENTOR WING STOL

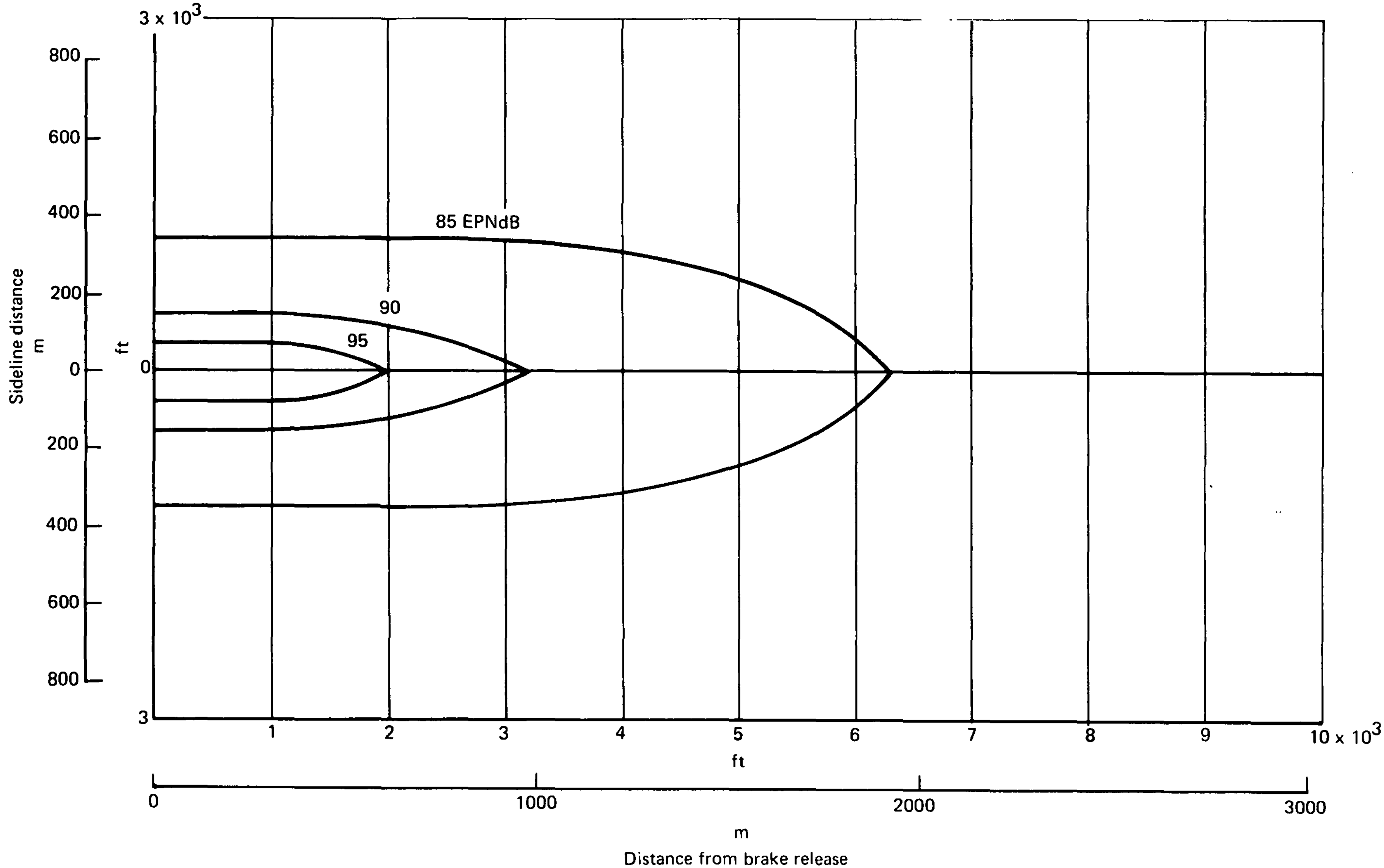

FIGURE 7-9.—TAKEOFF NOISE CONTOUR—1985 AUGMENTOR WING STOL

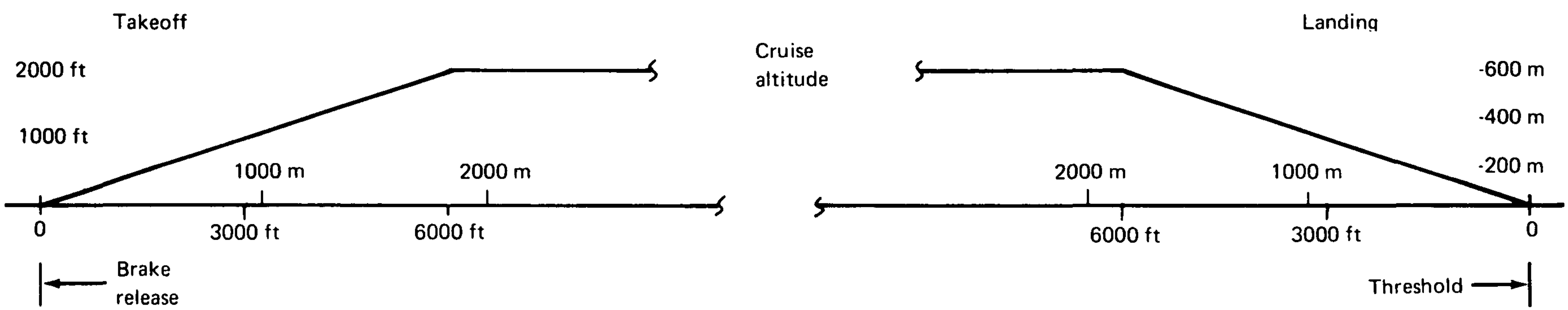

FIGURE 7-10.—HELICOPTER FLIGHT PROFILE

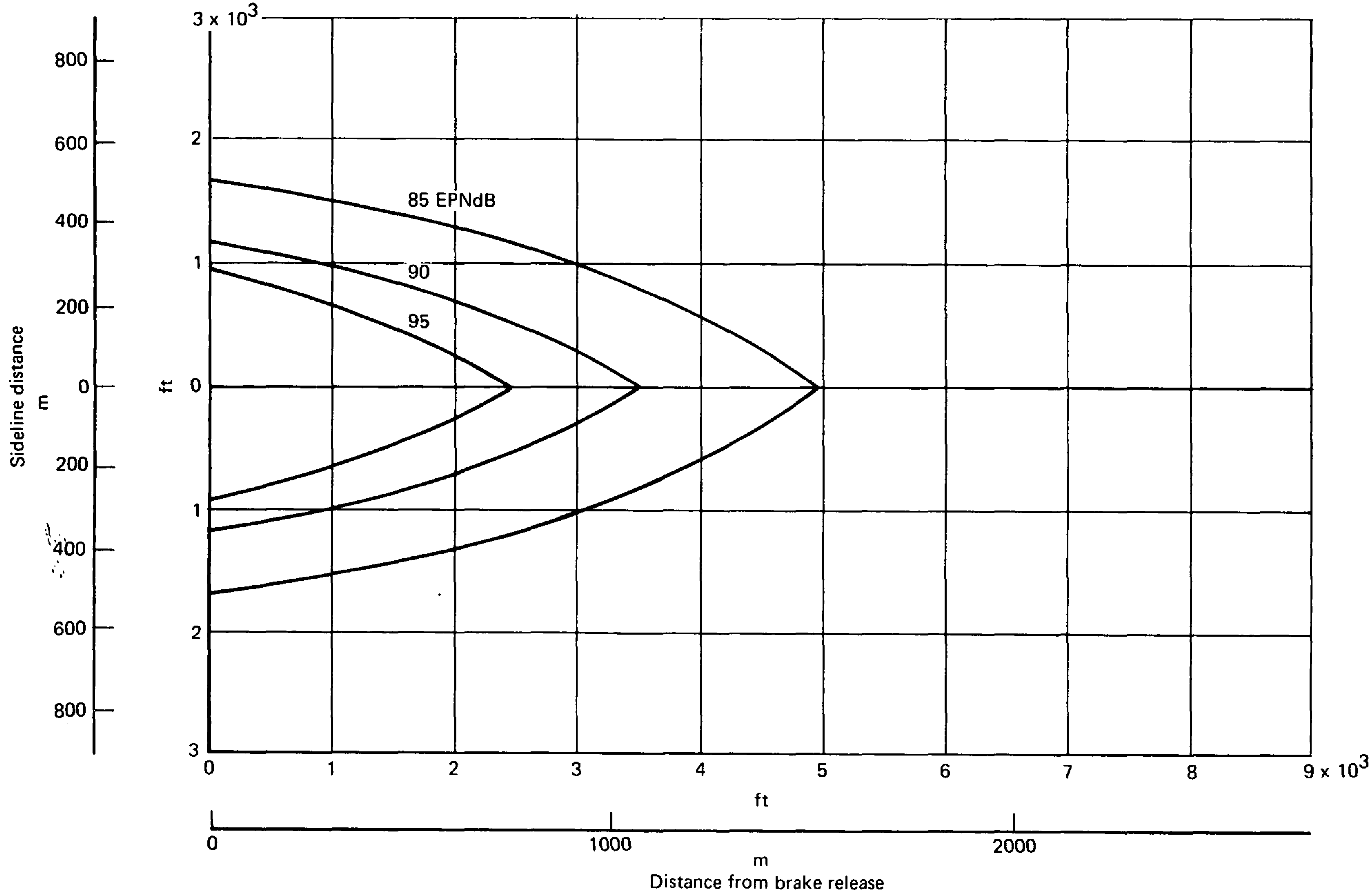

FIGURE 7-11.—TAKEOFF NOISE CONTOURS—1975 HELICOPTER—100 PASSENGERS

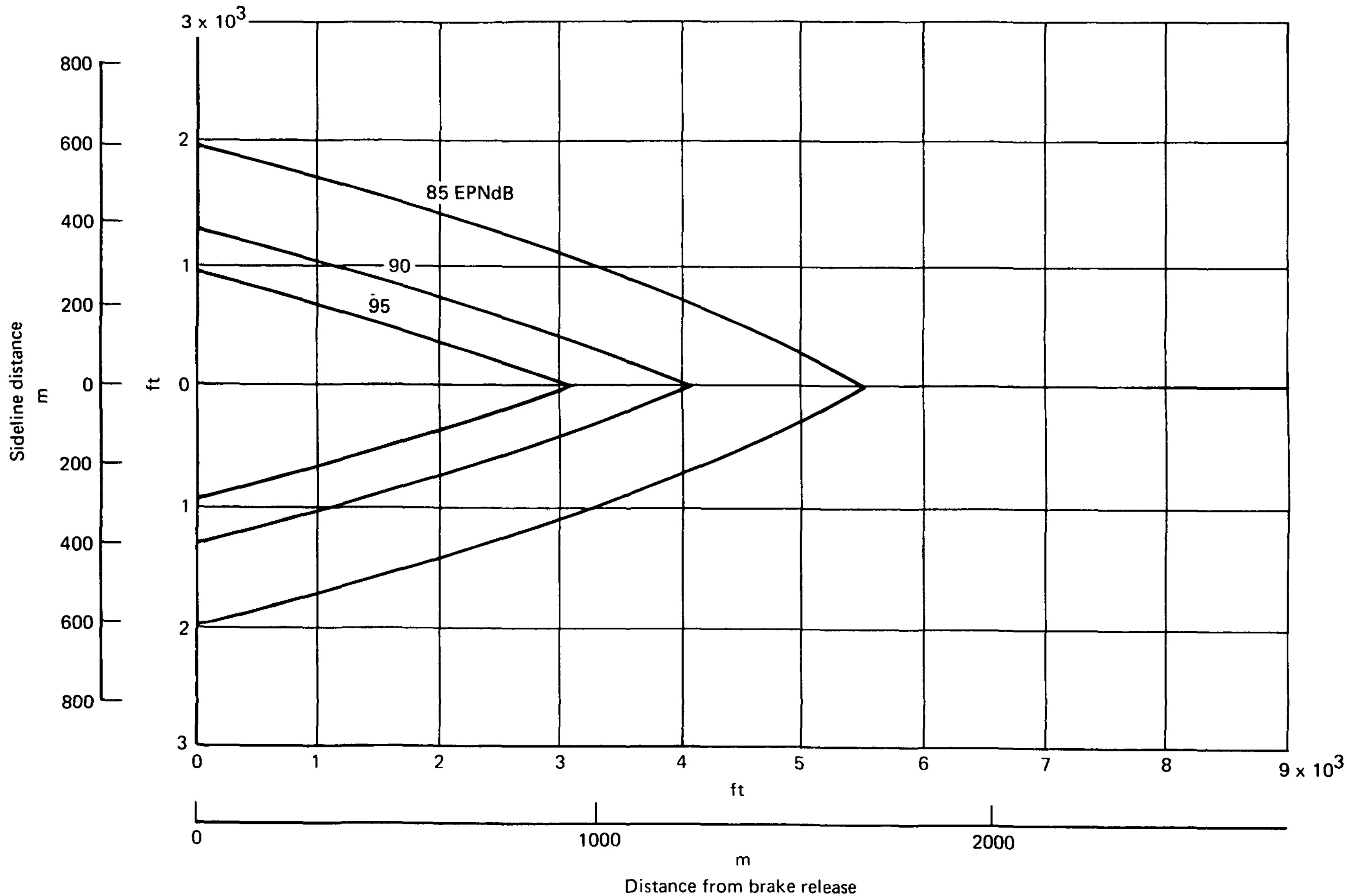

FIGURE 7-12.–TAKEOFF NOISE CONTOURS–1975 HELICOPTER–150 PASSENGERS

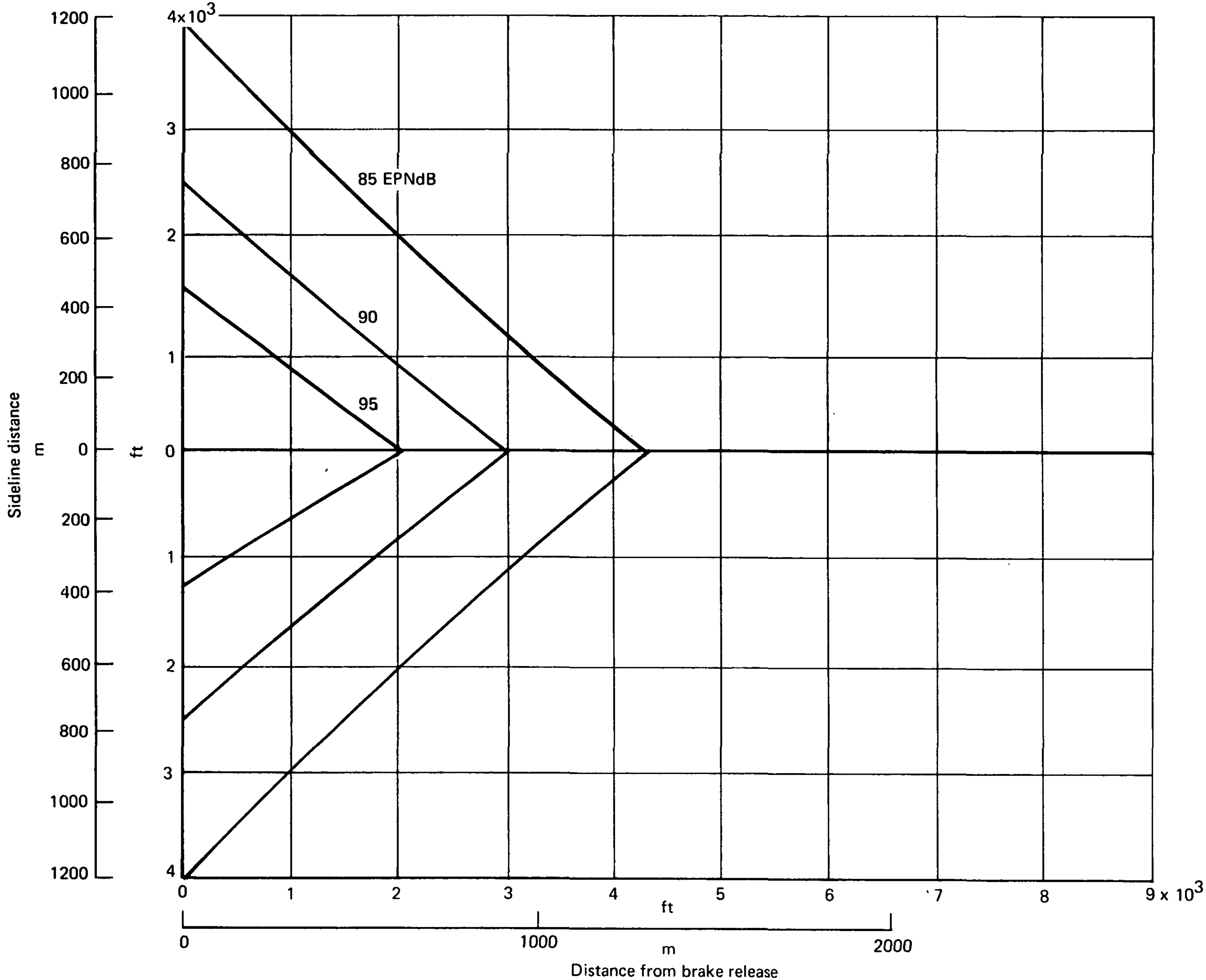

FIGURE 7-13. TAKEOFF NOISE CONTOURS—1985 TILT ROTOR—100 PASSENGERS

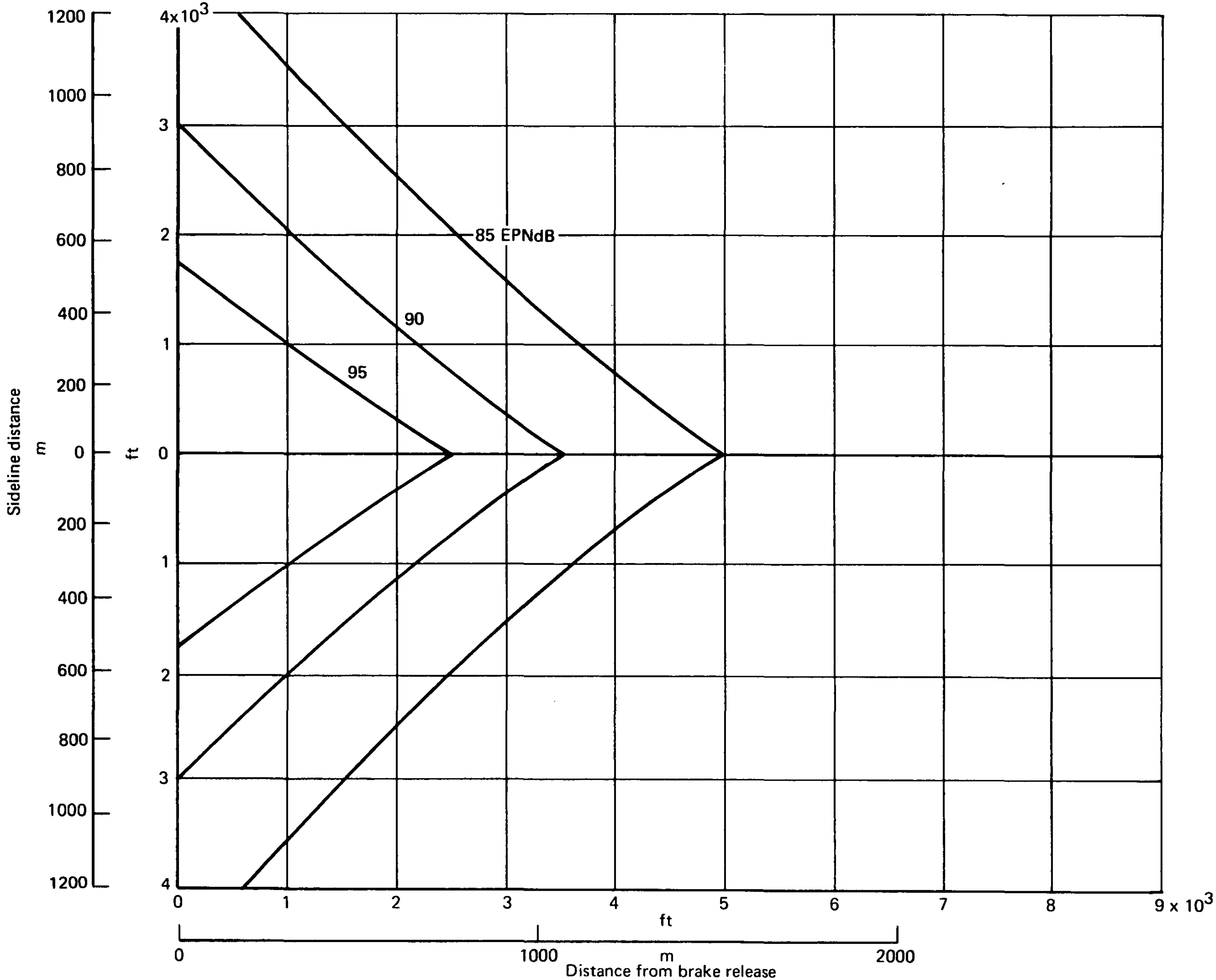

FIGURE 7-14.—TAKEOFF NOISE CONTOURS—1985 TILT ROTOR—150 PASSENGERS

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8.0 GROUND SYSTEMS ANALYSIS

8.1 TYPES OF AIR TERMINALS

In this study, air terminals are categorized as follows:

- Type A–Ground-level STOLport at existing airport
- Type B–Ground-level STOLport at undeveloped site
- Type C–Rooftop STOLport, downtown or at marine site
- Type D–Rooftop STOLport at major air carrier airport
- Type E–Ground-level VTOLport
- Type F–Rooftop VTOLport, downtown or at marine site
- Type G–Rooftop VTOLport at major air carrier airport

8.2 TERMINAL LOCATIONS

The site selection of air terminals was based on consideration of the following factors: noise and compatible land use, aircraft design–STOL or VTOL, ATC considerations, location of passenger origination and destination, obstacles and protection surfaces, existing airport facilities, ground access, air terminal costs, land costs, and weather considerations.

8.2.1 Community Noise and Compatible Land Use

An important aspect of an intraurban transportation system is that the VTOLports or STOLports be so located as to be "good neighbors" from a noise standpoint. Of course, the quieter the air vehicle, the more readily an air terminal can be sited for use by this vehicle. However, if the aircraft has moderate noise, it may still be possible to find a suitable air terminal location if the site is in the midst of open areas, industrial and commercial areas, or areas used for outdoor recreation. The noise section of this study gives noise data on the individual air vehicles and discusses the effect of aircraft operational frequency and ambient noise level in the overall consideration of noise to produce a noise exposure forecast, NEF_A. Table 8-1 illustrates the values of NEF_A suitable or unsuitable for various land uses.

Figures 8-1 through 8-8 show the noise footprints of the various airplanes for the indicated conditions of flight frequency and background noise superimposed on community maps of typical air terminal sites.

8.2.2 Aircraft Design–STOL or VTOL

A VTOL will not require as much land area for the air terminal as will a STOL vehicle. Also, due primarily to the steeper climb and descent angles of the VTOL, its noise footprint

is smaller than that of the STOL. Since the STOL vehicle is generally restricted to a definite route on departure from and approach to the air terminal, the VTOL, which is not so restricted, has a much wider number of potential air terminal sites available. For these reasons, a VTOLport may be located in an area satisfying other demands, such as ground access and proximity to passenger O and D, where location of a STOLport in such an area may not be possible.

8.2.3 ATC Considerations

Air terminals should be sited so that the STOL and VTOL approach and departure paths do not interfere with CTOL traffic or navigation signals. For STOLport and VTOLport siting at existing airports, use of existing CTOL procedures on the CTOL runways will generally suffice where the CTOL traffic does not overcrowd the existing runway capacity. Where the existing CTOL runway is at or near capacity, parallel STOL runways should be considered. Future technology is projected such that a minimum separation of 3000 ft (915 m) between parallel STOL and CTOL runways should be acceptable.

For other locations, the site will generally be satisfactory if it is 5 mi (8.05 km) or more from an existing CTOL airport and if general consideration is given to the paths of CTOL aircraft on landing and takeoff to and from these existing airports. In any event, all sites selected are given thorough ATC analyses by competent ATC personnel.

Projected IFR navigation equipment will allow a maximum of 41 one-way operations (landings or takeoffs) per hour for each STOL runway. Unless the parallel separation is sufficient, adding runways to the STOLport will not increase its capacity. Therefore, where high passenger volume is required at an air terminal, multiple STOLport sites, parallel STOL runways with 3000 ft (915 m) or more separation, or use of the high-capacity VTOLport may be required.

8.2.4 Location of Passenger Origination and Destination

For use in air terminal site selection, especially for the preliminary sites, the use of suitable maps of the area suffice. The land use, population density, and employment density maps of the San Francisco area of reference 2 are indicative of the probable locations of passenger origination and destination. The marketing computer analysis, showing the suitability of the preliminary sites, is used to refine air terminal site selections.

8.2.5 Obstacles and Protection Surfaces

The air terminal is located so that vertical obstacles, such as tall buildings, towers, mountains, etc., do not penetrate the prescribed protection surfaces. Reference 25 defines the protection surfaces for STOLports. Protection surfaces for VTOLports are discussed in section 8.4.2.

8.2.6 Existing Airport Facilities

Location of air terminals, especially STOLports, at existing airports should always be considered where other location factors are not unduly sacrificed. At existing airports, the

required land and some facilities are already available. The land surrounding the airport has probably been previously zoned for airport-compatible uses, and the local residents are acclimated to the existence of air operations in the area. If the airport is an air carrier airport, the intraurban air terminal makes an appropriate interface for passenger transfer. The existing CTOL runways may have sufficient unused runway capacity to also accommodate the required STOL traffic.

8.2.7 Ground Access

Air terminal siting that considers the existence or planning of future ground transportation systems may significantly reduce the cost of the air terminal by reducing the ground access costs. Also, the convenience of the intraurban system to its customers may be significantly affected by the terminal location with respect to ground access facilities. The siting of the air terminal over or near railroads. rapid transit lines, or freeways may well improve its acceptability from a noise standpoint because of the noise produced by these other modes of transportation. (See sec. 7.0 of this document for the effect of ambient noise on overall air terminal community noise.)

8.2.8 Air Terminal Structure Costs

Traffic volume data and gate time will dictate the number of gates required at the air terminal, which in turn will be a major factor in determining the air terminal structure costs. However, there may be some choice as to the type of air terminal (see sec. 8.1) to be constructed. The structure cost for a rooftop STOLport or VTOLport is many times more than the equivalent facility located at ground level. However, the ground-level facility will require more land, which may make the total cost of the ground-level terminal greater than the total cost of the rooftop terminal. We can therefore conclude that air terminal structure costs must be considered as a factor in the evaluation of potential air terminal sites.

8.2.9 Land Costs

The cost of land for an air terminal is a significant item in the overall terminal cost. This is especially true when the STOLport or VTOLport is located in a downtown business area. As would be anticipated, historical land sales data show that the cost of land generally increases as the central business district (CBD) is approached.

The model formula developed and substantiated by reference 26 is considered representative of a reliable indication of this subject. The pertinent formulas for 1975 and 1985 land prices, updated in terms of 1970 dollars, are shown in figure 8-9. Separate curves and formulas are shown for 1975 and 1985 inasmuch as historical data show an increase in land prices of approximately 5.5% per year above the increase in the consumer price index. The validity of the formulas for distances beyond 10 mi is not known. In addition, land prices in locally depressed or prosperous areas may not be substantiated by the formulas. However, use of these formulas should prove satisfactory in a computer system analysis.

Where terminals are constructed over existing facilities or land control under clear zones is required, a figure of 75% of bare land costs is reasonable for the required air rights.

8.2.10 Weather Considerations

Weather conditions vary slightly with geographical location within the study area (ref. 27). An average of about 25 days per year will have an occurrence of less than 0.5-mi (0.8 km) visibility (ref. 28). Approximately 90% of the air operations in the Bay area are under VFR conditions and 10% under IFR conditions (ref. 27). Since the intraurban vehicle is designed with IFR capability, visibility conditions should not influence the operation of the system and therefore should not be a factor in determining air terminal location.

In the study area, the surface winds have a speed greater than 17 kn (31.5 km/hr), an average of about 3% of the time and a speed greater than 28 kn (58 km/hr) an average of about 0.15% of the time (ref. 28). Since the VTOL will be able to select the most advantageous direction for operations with wind, and since the STOL vehicle will have crabbed steering provisions and will have a crosswind capability of 38 kn (70.5 km/hr), it is not anticipated that wind velocity will be a factor in the selection of air terminal sites. However, in the final design of any STOLport in the system, full consideration should be given to local winds in determining the STOL runway alignment so as to minimize the number of landings in crosswind conditions. For this intraurban study area, the prevailing wind blows from the northwest (ref. 29). Section 8.4.2 discusses the influence of wind on VTOLport design criteria.

Wind tunnel studies of airflow around buildings indicate that strong shear forces and turbulent eddies are formed over and in the lee of buildings. Full consideration of this factor should be given in design and location of air terminals in downtown areas.

8.3 AIR TERMINAL SITE SELECTIONS

To provide initial data for system computer analyses, preliminary air terminal sites were selected in the 30 geographical areas designated as "super zones" in the nine-county study area. The criteria of section 8.2 above were used as practicable in making these site selections. Following the various sensitivity studies described in section 11, the preliminary sites were further evaluated and relocated as indicated. Some additions and deletions were made. Changes were made as a result of more detailed studies of such items as noise and ground access. The sites determined for the 1980 base case, using the 49- or 50-passenger air vehicle with a 3-min gate time, are shown on figures 8-10 and 8-11 and are described in table 8-2.

8.4 TERMINAL DESIGN

8.4.1 Primary Intraurban Terminal Design Criteria—Facilities for Minimum Turnaround Time

Computer analyses confirm that every effort must be made to minimize the vehicle ground time and ground servicing personnel to maximize the system profit potential. The intraurban system will not require the following ground services normally performed at CTOL air carrier stops: air conditioning service, ground power service, galley service, water service, toilet service, air start service, and tow tractor service. Due to the short duration of

each stop, the main engines will not be shut down. Walk-around maintenance checks and cabin cleaning will not be accomplished at each stop. It is envisaged that such services will be performed at night and during off-peak-hour periods. Thus, the required ground servicing items are passenger handling, baggage handling, and fueling.

8.4.1.1 Passenger Handling

The basic intraurban vehicle has been configured to expedite passenger loading and unloading. This is accomplished by use of the "European train" concept with full fuselage width compartments and both left and right side sliding doors. To provide the terminal interface with the rapid passenger handling potential of the basic vehicle, a terminal passenger capsule will be required for positioning on each side of the aircraft. These capsules will elevate or move on tracks as necessary to mate the capsule doors with those of the aircraft. Such semienclosed terminal passenger transfer equipment is also considered required due to the safety aspects relative to the continuously operating main engines.

A combination of gate slab guides, visual aids, and perhaps semiautomatic control will be required to assist the pilot in properly positioning the air vehicle with respect to these passenger load and unload facilities.

Passengers will deplane through the right side airplane doors and will enplane via the left side doors. This type of operation allows passengers to commence loading via the left side doors prior to departure of all passengers through the right side doors. Figure 8-12 shows that an entire passenger exchange can take place, for the 95-passenger configuration, in approximately 1 min. This evaluation is based on a very conservative deplaning rate of 20 passengers per minute per door and an enplaning rate of 17 passengers per minute per door.

8.4.1.2 Baggage Handling

A centrally located baggage compartment with large right and left side doors will be provided in the intraurban vehicle. Two standard containers will be carried in this compartment for passenger baggage. Appropriately located baggage compartments will be provided in the passenger handling capsules for the incoming and outgoing baggage containers. A powered transfer system is envisaged for loading and unloading the baggage containers. The airplane baggage compartment may or may not be convertible for use as a passenger compartment when the air vehicle is on routes other than to or from a major air carrier airport.

8.4.1.3 Semiautomatic Fueling

A single fuel receptacle will be located on the underside of the air vehicle fuselage to mate with a semiautomatic fueling nozzle that will elevate from a recess in the gate slab. In servicing, one man will be required to monitor the operation of this fueling system. Details on the aircraft fuel capacity and frequency of fueling have not been developed. In any event, it is not planned that fuel servicing will determine the length of the ground servicing time.

8.4.1.4 Servicing Times

Typical sequences of ground servicing and the servicing personnel required for STOL and VTOL ground operations are shown on figures 8-13 and 8-14. Actual operations may prove that the ramp captain is able to perform the fuel monitoring function.

8.4.2 VTOLport Design Criteria

Limited information on VTOLport design criteria is provided in reference 30. However, certain aspects of reference 31 do not appear applicable to the future VTOL operations envisaged in this intraurban study.

Boeing investigations indicate that VTOL craft are much more sensitive to crosswind operations than are either STOL or small CTOL vehicles and that passengers won't accept true vertical landings. Therefore, it appears that an approach and landing capability must be provided for VTOL craft that permits "weathercocking" into all or most directions from which the wind would be expected to blow. The VTOL approach, although steeper than STOL, is still accomplished at an angle much less than 45°. This means that a set of standardized approach and departure paths about each VTOLport, connecting with the en route airspace, must be provided. These paths will be steeper and shorter than those provided STOL aircraft. Depending on the distribution and intensity of wind about the VTOLport, a multiplicity of approach and departure paths must be provided. From the above, it can be concluded that the linear approach and departure path specified for heliport operation by reference 30 is not appropriate for use with future VTOL operations. Also, the multipath approaches and departures would have the advantage of allowing dispersion of noise concentrations on the various land areas around the perimeter of the VTOLport.

From the basic design criteria for an intraurban air terminal that the vehicle ground time be minimized, it follows that the VTOL craft should land directly at its gate position in lieu of at a specified landing pad followed by taxi to a designated gate. Technology, both in aircraft and in IFR navigation aids, makes possible landing and takeoff from and to any direction. Simultaneous landings and takeoffs to and from adjacent gates under IFR conditions are feasible provided that the respective flightpaths do not conflict, that no shadowing of the navigation system signal occurs, and that air operations on takeoff and landing do not pass directly over adjacent pads when those pads are occupied.

Figures 8-15 and 8-16 present VTOLport design criteria that were developed from the above discussion. The circular gate area dimensions are a logical transition from the criteria of reference 30 to provide for the multi-directional nature of VTOL operations. The 6:1 (about 10°) slope of the conical protection surface should provide adequate vertical separation from the intended VTOL craft approach and departure paths of about 15° or more.

Figure 8-17 shows possible VTOLport layouts that would result from use of the above criteria.

8.4.3 STOLport Design Criteria

Generally the criteria of reference 25 are considered suitable for use in STOLport design for the intraurban system. For this study and primarily for safety purposes on rooftop STOLports, runway width has been increased to 150 ft (45 m), runway length to 2000 ft (610 m), and the safety area beyond the runway threshold to 150 ft (45 m).

Grooved runways should be provided to improve the overall safety of operations at a minimum cost.

Figures 8-18 and 8-19 depect two concepts of rooftop STOLports.

8.4.4 Gate Requirements

The number of gates required at an air terminal is a function of the frequency of aircraft movements and the gate servicing time. Figure 8-20 shows this information. Of significance is the limitation on the number of gates for a single-runway STOLport. (See sec. 8.2.3.) Data are given for 3-, 8-, and 11-min gate times to correspond with inputs to computer system analyses.

8.4.5 Ground Transportation Interface

The intraurban air system should be integrated with existing and planned area transportation systems. Rapid transfer is a necessity between the intraurban air terminal and highway, rapid transit, other air, and perhaps rail and marine transportation. Construction of the intraurban air terminal above or adjacent to these ground transportation facilities is the preferred method of providing this rapid transfer feature. The location of intraurban air terminals at downtown sites may well eliminate the need for planned highway and rapid transit systems. However, in the design of each individual air terminal, full consideration must be given to the influence of the air terminal on the ground transportation systems in the immediate vicinity and on those that will "feed" the air terminal.

It is anticipated that intraurban air terminals at major air carrier airports would actually reduce the existing ground congestion and that massive projects to extend additional freeway and rapid transit systems to these airports could be cancelled.

8.4.6 Air Terminals at Existing Major Air Carrier Airports

A large portion of the passenger volume carried by the intraurban sytem will be to and from the major air carrier airports at San Francisco and Oakland. At San Francisco International Airport, the preferred intraurban air terminal location is atop the CTOL terminal building. STOL runways parallel to the main SFO CTOL runways will be required with a minimum parallel runway separation of 3000 ft (915 m). Whether the existing, current, or planned construction at the CTOL terminal will allow such an intraurban facility to be built is not known. However, such a location represents the best location, especially as to ground access, ATC considerations, and compatibility with existing airport facilities.

At Oakland International Airport, various locations for ground-level and elevated STOLports and VTOLports were considered. However, it was determined that the best air terminal location to serve Oakland International Airport would be a ground-level site southwest of the Oakland-Alameda Coliseum. The passenger terminal of this air terminal would be connected to the tracked shuttle system planned to tie together the Coliseum, the Oakland International Airport, and the nearby BARTD station. This air terminal location would be better able to serve the local passenger origin and destination as well as the off-hour activities at the Coliseum.

8.4.7 Air Terminals at Ground-Level Locations or at Existing Small Airports

The majority of the air terminals will be located at sites where construction of ground-level facilities will be possible and most economical. Many of these will be located at existing small airports where adequate land is available for ground-level construction.

Typical small airports in the study area were examined in detail as to their overall suitability for use in the intraurban system, for practicality of using feasible ground servicing procedures, and for developing the cost estimates of section 8.4.9.

8.4.8 Maintenance Facilities

To better understand the cost of the intraurban maintenance facilities, the land area required, and the impact of maintenance requirements on the system, a basic maintenance plan is included here. The plan is developed around a fleet of 80 augmentor wing STOL aircraft.

8.4.8.1 Facilities Requirements

Because of high use of the aircraft during the day, the basic concept considered here accomplishes most maintenance during the hours from 9:00 pm to 5:00 am. All scheduled maintenance will be accomplished in increments during these hours so that no spare aircraft will be required due to overhauls, etc.

A centralized maintenance control facility and two satellite maintenance bases are provided for maintenance and overhaul. A suitable shop and hangar facility for centralized maintenance and overhaul is shown in figure 8-21.

The central maintenance control facility could be located anywhere in the San Francisco Bay area, but preferably at a small suburban airport also serving as an intraurban air terminal. Figure 8-22 depicts the location of the shops and hangars shown in figure 8-21 at the Napa County Airport. The satellite maintenance bases could be located at intraurban air terminals on the periphery of the system. Suggested locations are Livermore and Morgan Hill. A hangar and shop complex is shown in figure 8-23 for a satellite base.

Central maintenance should include the following shops. (Shops required at satellite maintenance facilities are starred.)

- Instrument

- Avionic and electrical
- Hydraulic
- Engine overhaul–major
- Wheels, tires, brakes*
- Sheet metal and seat repair*
- Engine replacement*
- Pneumatics
- Standard and special tool rooms*
- Engine test cell

Space should be provided at each maintenance facility to park at least 20 airplanes. Figures 8-21 and 8-23 show hangar space for four airplanes at each facility with room for future expansion.

The central control facility would be capable of conducting the A, B, C, and D checks. Briefly, these checks consist of the following:

- A check–Thorough visual check for airworthiness, generally without removal of panels
- B check–Thorough visual check, opening certain access doors and panels, some lubrication and filter replacement, and selected operational checks
- C check–Thorough detailed inspection to determine continued airworthiness, system functional operational checks, complete lubrication, and recalibration of some components
- D check–All items in previous checks, lubrication, calibration, component replacements as necessary, and thorough structural inspection

The satellite bases should be able to accomplish A and B checks. All checks and tasks can be accomplished at the central control base. A checks that are required each day on portions of the fleet could be accomplished at gate positions, but, if unscheduled maintenance developed, the airplane could be replaced with one from a maintenance base. The C and D checks should be scheduled at the main base on an incremental basis. For example, a structural inspection of the horizontal stabilizer could be accomplished overnight as a part of the D check.

Unscheduled maintenance on tires, brakes, engines, flap actuators, etc. will disrupt the entire route schedule for that airplane and will strand or delay passengers. Mobile

maintenance teams and replacement airplanes (minimum of 2% of the fleet) should be available immediately.

Central maintenance should be provided with computer services to track component time, program increments of maintenance checks, and various other tasks.

Approximately 320 000 sq ft (29 700 sq m) are allowed for shop facilities, excluding the test cell but including spares storage space. The following breakdown for "brick and mortar" for one main base and two satellite bases shows a total of approximately $13 million.

Satellite shop area	48 000 sq ft (4 460 sq m)
Central base shop area	320 000 sq ft (29 700 sq m)
Hangar area at each base	57 600 sq ft (5 350 sq m)
Shop cost	$20/sq ft ($186/sq m)
Hangars	$26/sq ft ($242/sq m)

The above costs include general construction, electrical, plumbing, heating, ventilating, air conditioning, and fire protection. The test cell cost is estimated at $430 000.

Central base cost

320 000 x 20 =	$6 400 000
57 600 x 26 =	1 500 000
Test cell =	430 000
Total =	$8 330 000

Satellite base cost

48 000 x 20 =	$ 960 000
57 600 x 26 =	1 500 000
Total =	$2 460 000

Two satellite bases = $4 920 000

Grand Total = $13 250 000

The cost of overhaul equipment and required shop equipment will vary from $4 to $7.5 million. The amount will vary within this range due to many factors such as amount of overhaul work subcontracted in lieu of buying equipment, the wide range of vendor prices, the selection of equipment, etc. For this study, a figure of $6 million will be selected to outfit the shops, equip the test cell, and obtain the special tools and test equipment required for engine overhaul (approximately $420 000) and other aircraft component overhaul.

The cost of maintenance tools for the system is estimated at $2.01 million. This number was derived from actual tool requirements by ATA breakdown for 707, 727, and 737 aircraft.

The total maintenance investment for an 80-airplane fleet is now:

Buildings	$13 250 000
Overhaul equipment	6 000 000
Tools and stands	2 010 000
Total	$21 260 000

A similar analysis conducted for 60- and 100-airplane fleets yields the relationship of maintenance investment and fleet size shown in figure 8-24.

8.4.8.2 Maintenance Concepts

In addition to the concept just presented, other plans were investigated. These plans are described briefly here and summarized in table 8-3.

In plan 1, all 80 aircraft would be dispersed to three maintenance bases at night for scheduled or unscheduled maintenance.

In plan 2, 20 of the 80 aircraft are parked at the STOLports outside the downtown area and the remaining 60 are cycled through the maintenance bases. The number of satellite bases was reduced to two.

Plan 3 uses the central maintenance facility and three satellite bases with one airplane parked overnight at each of 40 gate positions. The remaining 40 airplanes are dispersed to the maintenance bases. Each gate position will require ground equipment such as engine plugs, hydraulic carts, and oil service.

Although only three plans have been considered, others may be evaluated by using a building-block approach. Plan 2 considered here was the basis for the maintenance system described in section 8.4.8.1 and the prices shown in figure 8-24.

8.4.9 Terminal Costs

The total air terminal cost consists of the sum of the costs of all the individual items required to provide the required air terminal for the time period under consideration. The air terminal may or may not be self-supporting, including payment of bond interest and principal, depending on the policy of ownership. Nevertheless, the initial cost of providing the ground facilities for this intraurban transportation system is a significant aspect of this study.

The following are pertinent items of air terminal costs that must be considered:

- Land
- Clear-zone air rights

- Flight deck
- Air vehicle parking aprons
- Control tower and ground air navigation equipment
- Access roads
- Structure
- Passenger terminal except for space for concessionaires
- Furnishings, equipment, and utilities
- A and E design fee and construction contingencies
- Clearing, grading, drainage, and demolition

The cost of the various air terminals will vary depending on (1) type of air terminal (see Sect. 8.1), (2) fixed costs such as control tower and ATC, (3) costs varying with the number of gates required, and (4) land costs. For the various types of air terminals, formulas for determining the air terminal cost are listed in table 8-4. These formulas can be used in computer analyses, or the terminal costs can be determined readily for the entire system from the outputs of computer analyses showing the required number of gates and from using the land cost data of figure 8-9.

In arriving at the formulas of table 8-4, the following criteria and assumptions were used:

- Costs are in 1970 dollars.
- Air terminal design criteria are as per sections 8.4.2 and 8.4.3
- Formulas include architect-engineer design fee and construction contingencies.
- A 3-min gate time is used.
- 49- or 50-passenger air vehicle is used.
- Gate layout, size, and equipment are planned to provide minimum cost with transition to the 100-passenger aircraft in 1990.
- Only the costs for the aviation-oriented facilities required by the air terminal are included; the cost of providing facilities for concession operators and excess space available for other rentals is assumed to be provided by others.
- STOLports at existing small airports are assessed 50% of land costs for a complete 2000-ft (610 m) runway STOL port but are assessed complete runway and taxiway costs.

- Clear-zone air rights for elevated downtown air terminals cost 75% of bare land costs.

- Control tower and ground air navigation equipment cost $5 million per air terminal.

- Air rights are required for 50 ft (15 m) outside VTOLport flight area.

- VTOLport flight area and flight area perimeter varies with number of gates, as shown on figure 8-25.

- VTOLports at existing small airports are assessed 100% of land costs, including air rights.

- Rooftop intraurban air terminals at major air carrier airports are assessed 50% land costs, zero air rights costs, and zero ground access costs.

Where known conditions at individual air terminal sites do not substantiate the above assumptions and criteria, the cost computation is varied accordingly.

Table 8-5 shows a summary of total air terminal costs, including land, for the intraurban system in 1980-base cases for VTOL and STOL. The 49- or 50-passenger aircraft will be used, and a 3-min gate time is assumed.

8.4.10 Alternate Air Terminal Use

The proposed air terminals for this intraurban system were evaluated for alternate use to determine whether the cost of the ground system might be shared with others not directly associated with the aviation activities of the intraurban network.

Aviation-oriented facilities or those ground facilities directly associated with and required by the intraurban system are: control tower; flight deck; passenger waiting rooms; cargo and baggage handling and storage spaces; passenger ticketing; restrooms; air terminal employee lounge; operations, administration, and maintenance offices and spaces; passageways, elevators and escalators; and interface with ground transportation systems. With the possible exception of the last two items, the above aviation-oriented facilities are not available for use by others.

Facilities for the following non-aviation-oriented uses, or concessions, are also normally associated with an airport: car rentals, limousines, taxis and buses; automobile parking and parking meters; restaurants, liquor, and snack bars; hotels and motels; advertising; flight insurance; coin-operated devices; personal services such as barber shops and shoe shine parlors; and specialty shops. These concessions also may serve many persons who are not users or employees of the air transportation system. Airport restaurants are very profitable and have proven successful in drawing a large percentage of their patrons from nonpassenger groups. In the proposed intraurban network, it is anticipated that many terminal automobile parking facilities would serve others as well as the air system employees and passengers. At air terminals at Berkeley heliport and Oakland-Alameda Coliseum the air terminal parking

could readily be shared with the nearby sporting activity patrons. A study of existing airport financial reports shows that substantial revenues are being realized from these concessions, even over and above bond interest and principal payments.

At the intraurban downtown air terminals, the required height of the structure generally will provide building space in excess of that required for both aviation-oriented and concession-oriented facilities. An evaluation of the cost of this excess space, as compared with the revenue that could be obtained from rental as office space or automobile parking in these downtown areas, indicates that a substantial profit can be made from such use of this excess space.

From the above studies, it was determined that the air terminal costs of section 8.4.9 should consist of only the cost of facilities directly associated with and required by the intraurban system. The cost of the non-aviation-oriented facilities and excess space would be financed separately, and their profits would be more than adequate to cover the cost of their construction. In fact, depending on the operating policy of this air terminal system, the profits from these facilities could be used to help defray the cost of construction and operation of the aviation-oriented facilities. Section 11.0 of this document further discusses this aspect.

TABLE 8-1.—LAND USE COMPATIBILITY CHART FOR AIRCRAFT NOISE—NOISE EXPOSURE FACTOR (NEF_A)

Land use compatibility	Noise exposure forecast areas		
	NEF_A less than 10	NEF_A between 10 and 15	NEF_A greater than 15
Residential	Yes	(b)	No
Commercial	Yes	Yes	(c)
Hotel, motel	Yes	(c)	No
Offices, public buildings	Yes	(c)	No
Schools, hospitals, churches	(c)	No	No
Theaters, auditoriums	(a) (c)	No	No
Outdoor amphitheaters, theaters	(a)	No	No
Outdoor recreational (nonspectator)	Yes	Yes	Yes
Industrial	Yes	Yes	(c)

[a] A detailed noise analysis should be undertaken by qualified personnel for all indoor or outdoor music auditoriums and all outdoor theaters.

[b] Case history experience indicates that individuals in private residences may complain, perhaps vigorously. Concerted group action is possible. New, single-dwelling construction should generally be avoided. For apartment construction, note (c) applies.

[c] An analysis of building noise reduction requirements should be made, and needed noise control features should be included in the building design.

TABLE 8-2.–AIR TERMINAL SITES–1980

Super zone no.	Site description	Latitude	Longitude	Site use VTOL	Site use STOL	STOL surface alignment[a]	Remarks	Airport type[d]
1	Offshore from Ferry Bldg	37° - 47'.8	122° - 23'.4	Princ	Princ	180/360	STOL surface 100 ft high min	F C
2	Crissy Field	37° - 48'.3	122° - 27'.5	–	Princ	(b)	(c)	– A
2	Intersection Geary and Presidio Blvds	37° - 46'.8	122° - 28'.3	Princ	–	–		F –
3	Marine site south of Mission Rock Terminal	37° - 46'.3	122° - 23'.0	–	Princ	170/350		– C
3	Intersection Central Skyway and Mission Street	37° - 46'.2	122° - 25'.1	Princ	–	–		F –
4	Fort Funston	37° - 43'.0	122° - 30'.0	–	Princ	110/290	(c)	– B
4	Daly City Bart Terminal	37° - 42'.4	122° - 28'.1	Princ	–	–		F –
5	San Francisco International Airport	37° - 37'.0	122° - 23'.0	Princ	Princ	(b)		G D
6	San Carlos Airport	37° - 30'.8	122° - 15'.0	Princ	Princ	(b)		E A
7	Palo Alto Muncipal Airport	37° - 27'.7	122° - 06'.9	Princ	Princ	(b)		E A
8	Los Altos Hills	37° - 21'.3	122° - 06'.9	Princ	Princ	100/280		E B
9	San Jose Municipal Airport	37° - 21'.6	122° - 55'.5	Princ	Princ	(b)		E A
10	Freeway intersection Los Gatos	37° - 13'.7	121° - 58'.3	Princ	–	–		E –
11	Reed Hillview Airport	37° - 20'.0	121° - 49'.0	Princ	Princ	(b)		E A
12	Morgan Hill Airport	37° - 09'.0	121° - 39'.0	Princ	Princ	(b)		E A

[a] °Magnetic [b] Same as airport runways [c] If available from DOD [d] See section 8.1

TABLE 8-2.—AIR TERMINAL SITES—1980—Concluded

Super zone no.	Site description	Latitude	Longitude	Site use		STOL surface alignment[a]	Remarks	Airport type[d]	
				VTOL	STOL				
13	Livermore Municipal Airport	37° - 41′.7	121° - 49′.0	Princ	—			E	—
14	Fremont Bart Terminal	37° - 33′.2	121° - 58′.3	Princ	Princ	120/300		E	B
15	Hayward Municipal Airport	37° - 39′.5	122° - 07′.0	Princ	Princ	(b)		E	A
16	Intersection McArthur Blvd and Bart Line	37° - 49′.7	122° - 16′.0	Princ	—	—	Over McArthur Bart Sta.	F	—
	Oakland south of Alameda Coliseum	37° - 45′.0	122° - 12′.6	Princ	Princ	130/310		E	B
17	Berkeley Municipal Heliport	37° - 52′.0	122° - 18′.5	Princ	Princ	150/330		E	B
18	San Pablo Bay	37° - 58′.8	122° - 21′.8	Princ	Princ	150/330		E	B
20	Buchanan Field	37° - 59′.3	122° - 03′.3	—	Princ	(b)		—	A
	SE of Pleasant Hill	37° - 55′.4	122° - 02′.5	Princ	—			E	—
21	Antioch Airport	37° - 58′.0	121° - 48′.0	Princ	Princ	(b)		E	A
22	Mare Island	38° - 07′.2	122° - 18′.2	—	Princ	060/240		—	B
	Vallejo Waterfront	38° - 05′.6	122° - 15′.2	Princ.	—	—		E	—
24	Napa County Airport	38° - 13′.0	122° - 17′.0	Princ	Princ	(b)		E	A
26	Cotati Naval Aux Air Station (inactive)	38° - 21′.0	122° - 43′.0	Princ	Princ	070/250	(c)	E	A
29	Gnoss Field	38° - 09′.0	122° - 32′.5	Princ	Princ	(b)		E	A
30	Corte Madera	37° - 56′.0	122° - 30′.4	Princ	Princ	110/290		E	B

[a] °Magnetic [b] Same as airport runways [c] If available from DOD [d] See section 8.1

TABLE 8-3.—MAINTENANCE CONCEPT SUMMARY

Facilities	Plan 1	Plan 2	Plan 3
Number			
Aircraft at central base	20	20	10
Number of satellite bases	3	2	3
Aircraft at each satellite base	20	20	10
Aircraft parked at gates	0	20	40
Cost			
Central base facilities	$ 8 330 000	$ 8 330 000	$ 8 330 000
Overhaul Equipment	6 000 000	6 000 000	6 000 000
Satellite bases	7 380 000	4 920 000	7 380 000
Maintenance tools:			
Central base	560 000	560 000	260 000
Satellite bases	1 280 000	850 000	630 000
Gates	–	600 000	1,210 000
Total	1 840 000	2 010 000	2,100 000
Total maintenance investment	$23 550 000	$21 260 000	$23 810 000

TABLE 8-4.—STOLPORT AND VTOLPORT COST FORMULAS

Type	Description	Costs[a], 1970 dollars in millions
A	Ground level STOLport at existing airport	9.0 + 1.0X + 76.0Y
B	Ground level STOLport	9.2 + 1.0X + 152.0Y
C	Rooftop STOLport, downtown or at Marine site	49.0 + 0.6X + 46.6Y
D	Rooftop STOLport at major air carrier airport	44.5 + 0.6X + 18.0Y
E	Ground level VTOLport	5.0 + 10X + (1.2 + 5.0X)Y
F	Rooftop VTOLport at downtown or marine site	9.0 + 2.46X + (0.9 + 1.9X)Y
G	Rooftop VTOLport at major air carrier airport	5.0 + 2.46X + 0.85XY

[a] X = number of gate positions required
Y = land cost per acre x 10^{-6}

TABLE 8-5.—1980 AIR TERMINAL COST SUMMARY[a]

STOLport			
Zone no.	Terminal type	No. of gates	Cost[b]
1	C	7	87.9
2	A	2	37.6
3	C	3	81.0
4	B	1	34.3
5	B	1	34.3
6	A	3	15.2
7	A	3	14.4
8	B	1	14.6
9	A	2	12.8
10	–	–	–
11	A	2	14.6
12	A	1	11.2
13	–	–	–
14	B	2	15.9
15	A	3	17.0
16	B	2	27.9
17	B	2	29.2
18	B	1	19.3
20	A	2	13.7
21	A	1	11.9
22	B	1	16.7
24	A	1	12.5
26	A	1	11.7
29	A	2	13.7
30	B	2	24.2
		Total	609.1

VTOLports			
Zone no.	Terminal type	No. of gates	Cost[b]
1	F	6	35.0
2	F	2	15.7
3	F	3	19.0
4	F	2	15.0
5	G	3	12.6
6	E	2	7.5
7	E	2	7.4
8	E	1	6.2
9	E	2	7.3
10	E	1	6.2
11	E	2	7.3
12	E	1	6.1
13	E	1	6.2
14	E	2	7.4
15	E	3	9.0
16	F	3	17.4
16	E	2	9.0
17	E	1	6.9
18	E	1	6.4
20	E	2	7.5
21	E	1	6.2
22	E	1	6.3
24	E	1	6.2
26	E	1	6.2
29	E	1	6.3
30	E	2	8.0
		Total	255.3

[a] 49-passenger airplane

[b] 1980 costs in 1970 dollars in millions

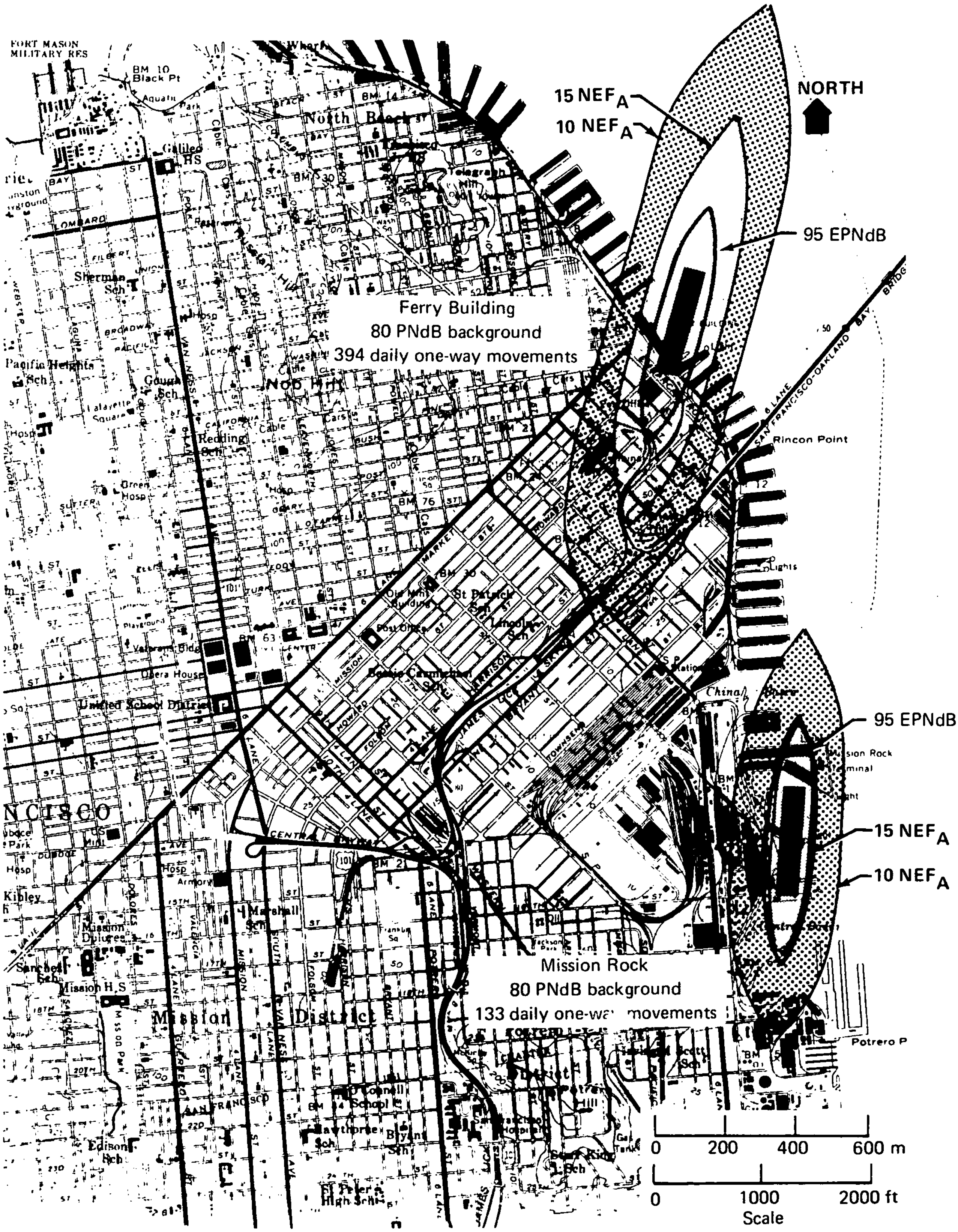


FIGURE 8-1.–COMMUNITY NOISE CONTOUR–STOL IN DOWNTOWN SAN FRANCISCO

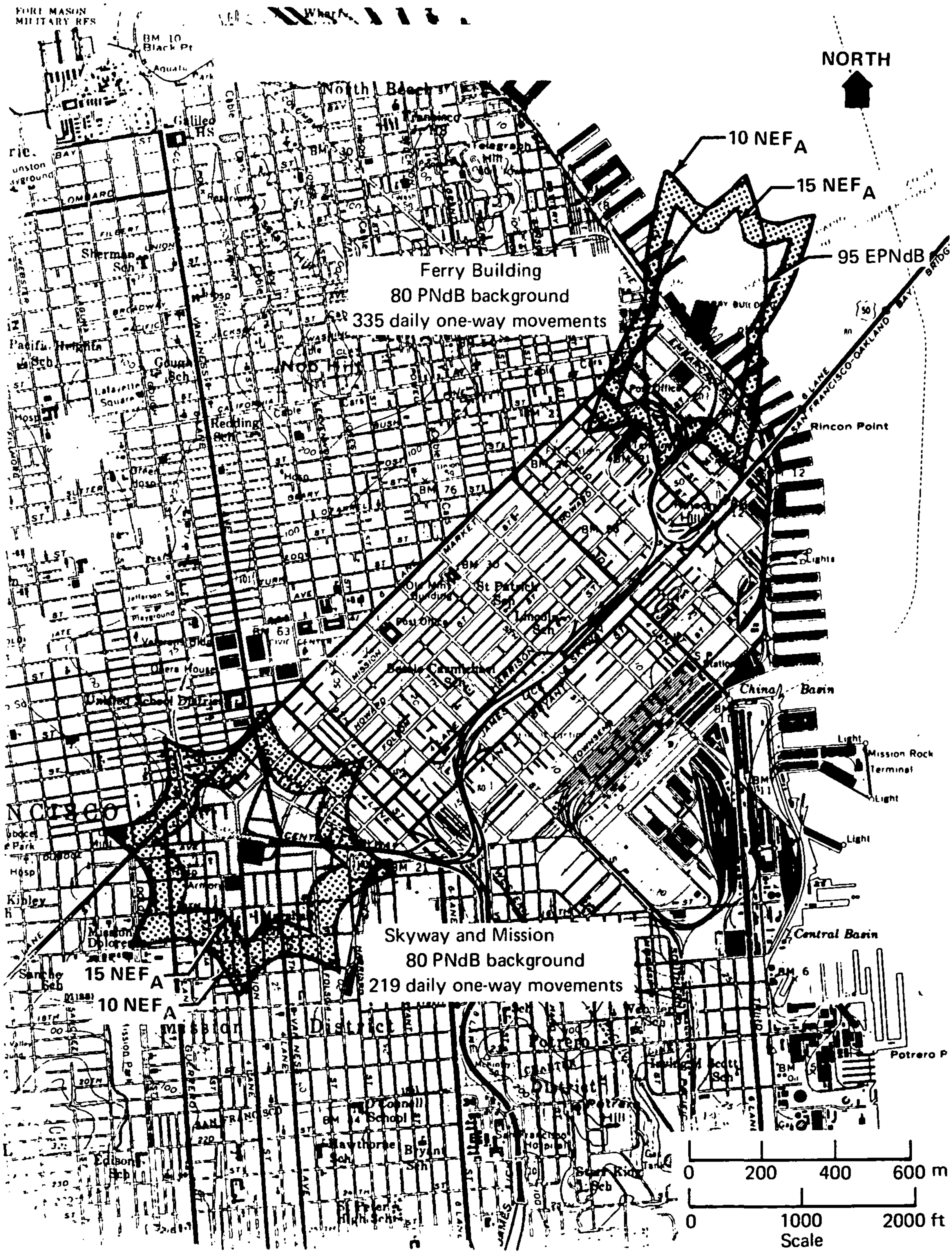


FIGURE 8-2.–COMMUNITY NOISE CONTOUR–HELICOPTER IN DOWNTOWN SAN FRANCISCO

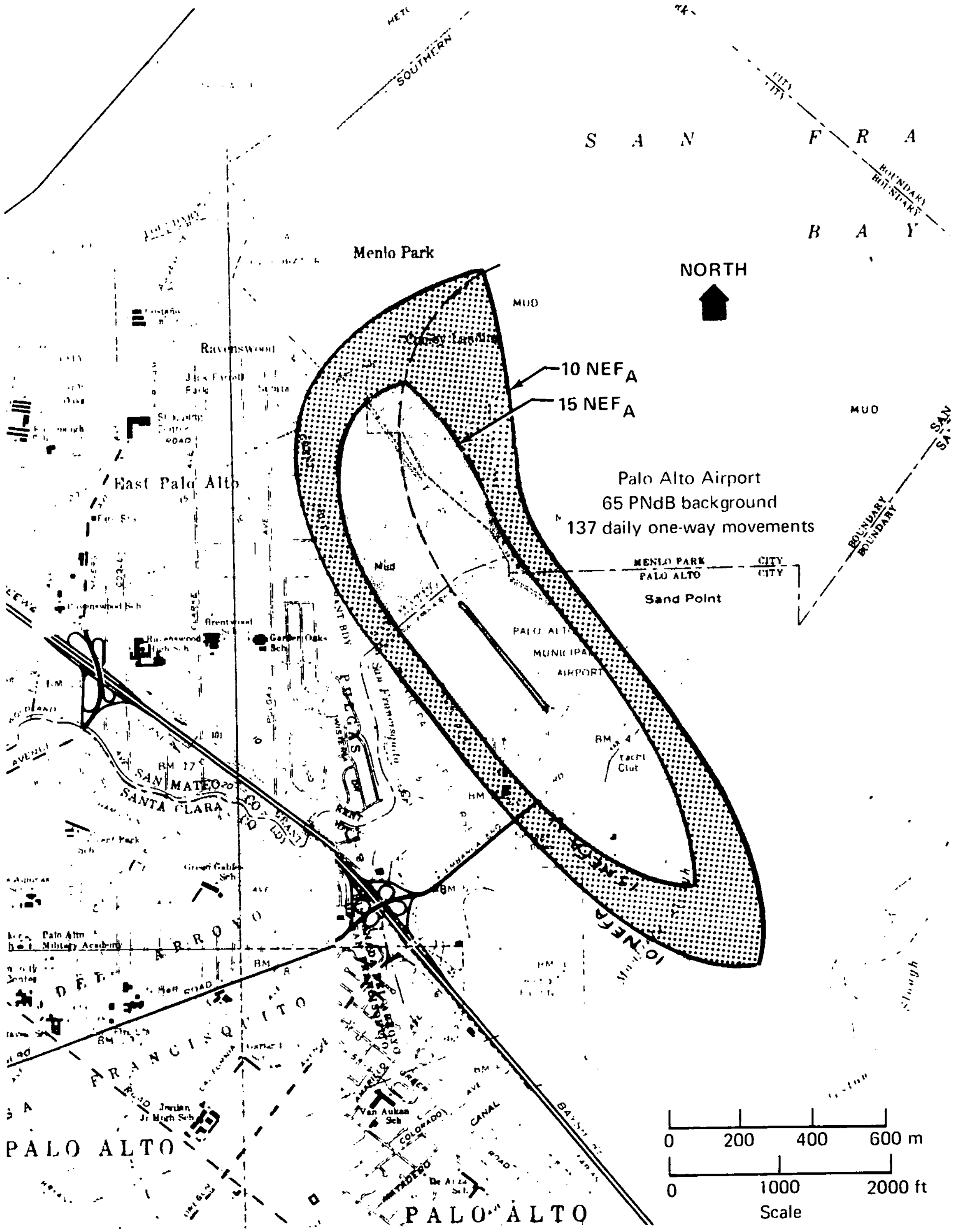


FIGURE 8-3. COMMUNITY NOISE CONTOUR–STOL AT PALO ALTO AIRPORT

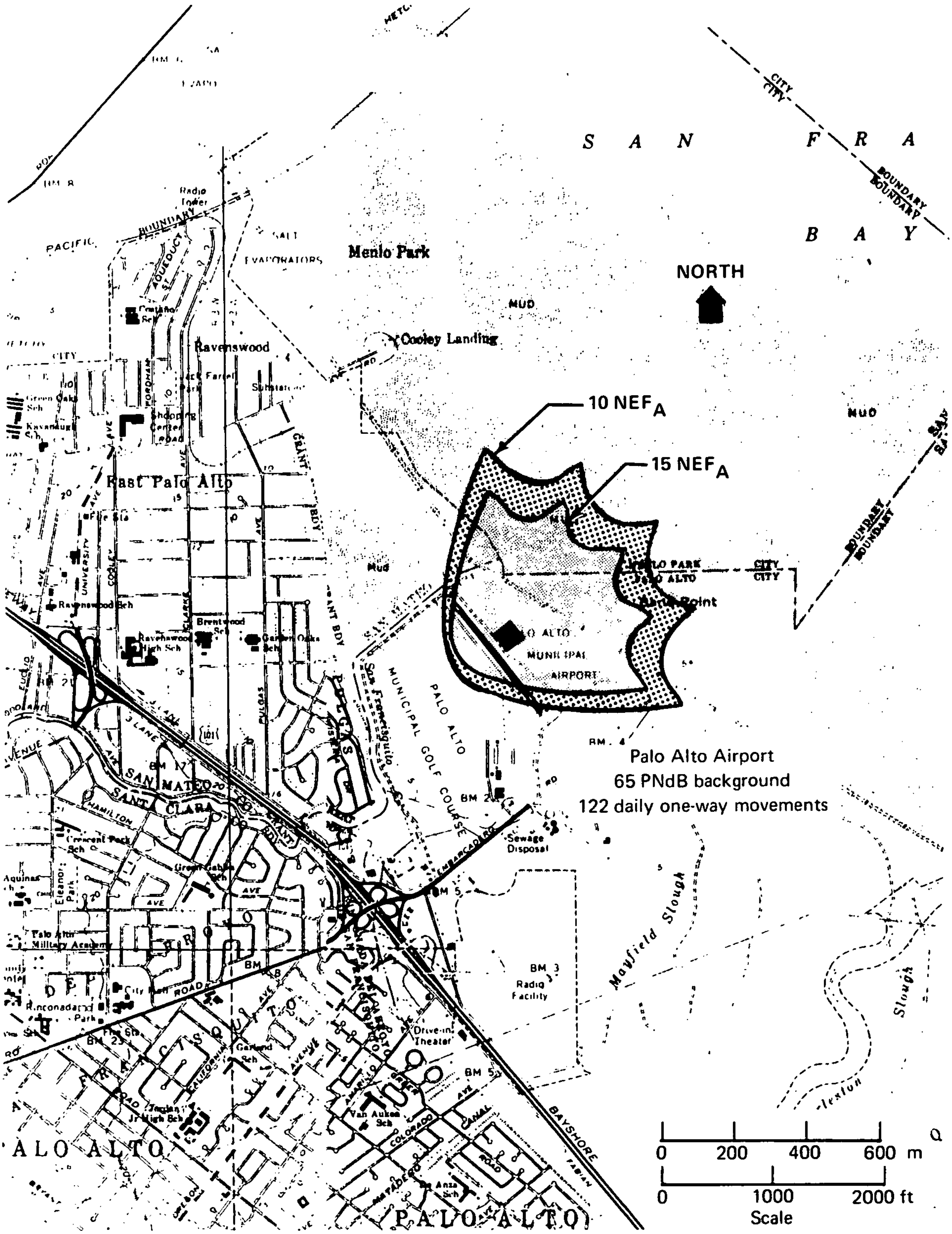


FIGURE 8-4.–COMMUNITY NOISE CONTOUR–HELICOPTER AT PALO ALTO AIRPORT

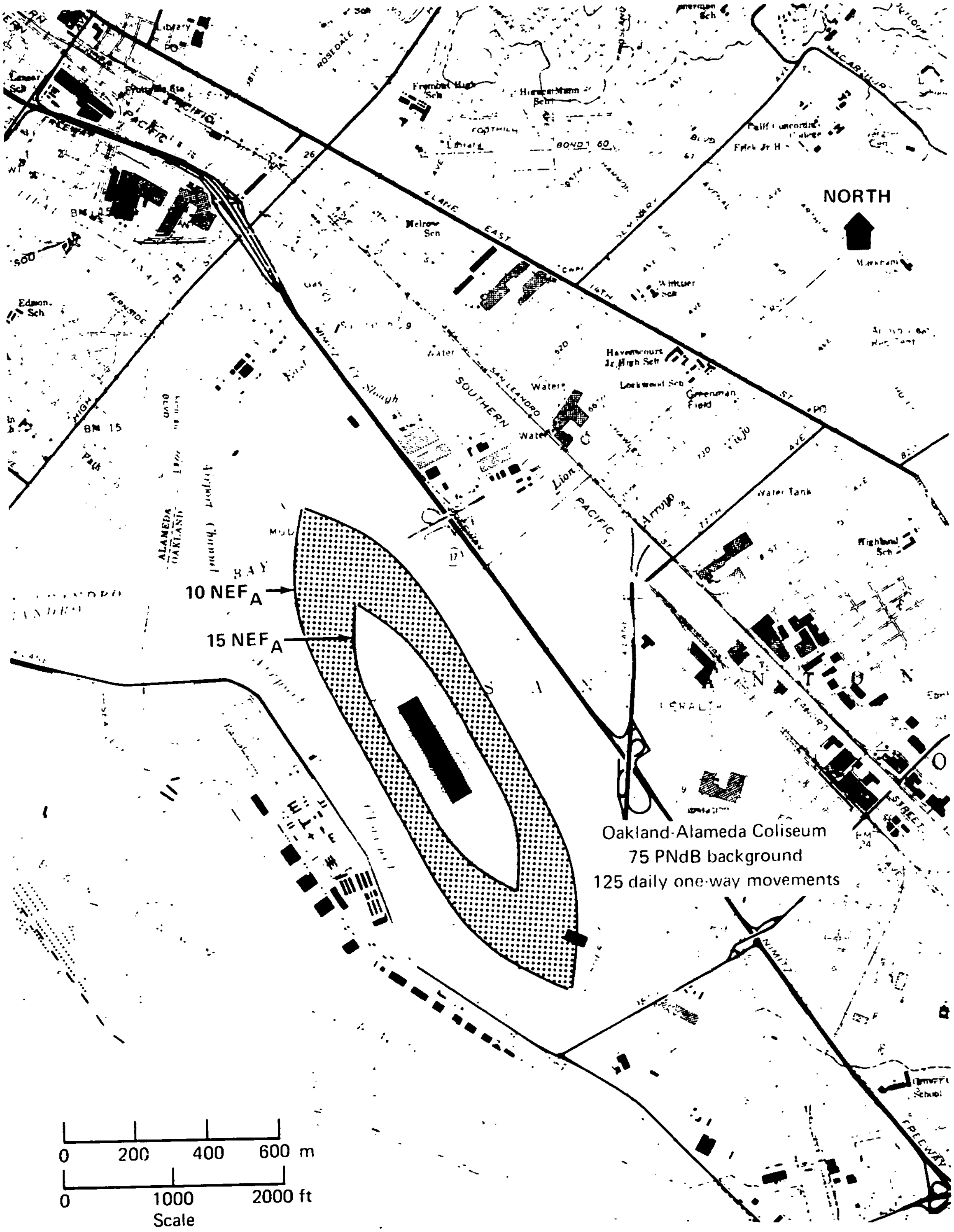


FIGURE 8-5.–COMMUNITY NOISE CONTOUR–STOL AT OAKLAND-ALAMEDA COLISEUM

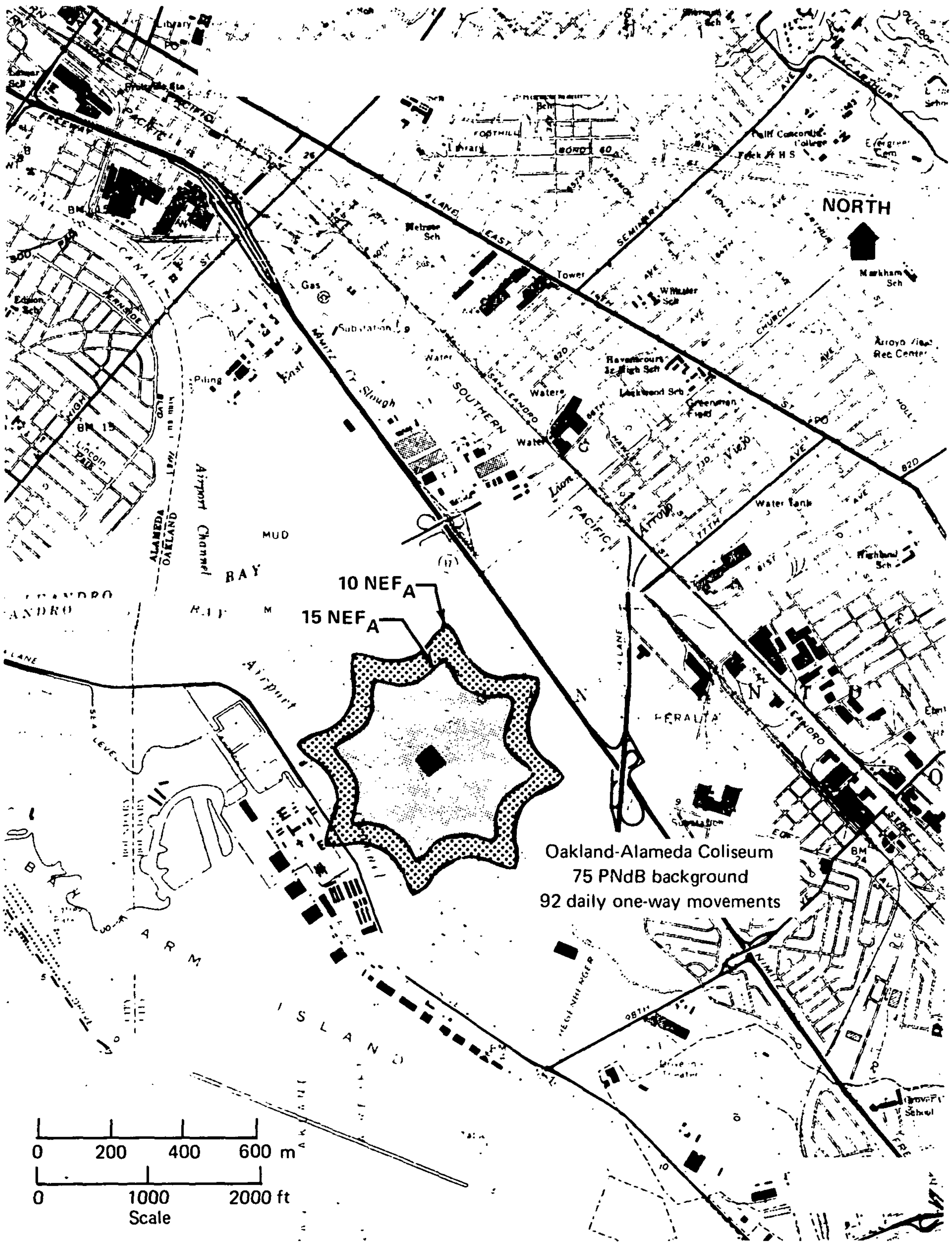


FIGURE 8-6.–COMMUNITY NOISE CONTOUR–HELICOPTER AT OAKLAND-ALAMEDA COLISEUM

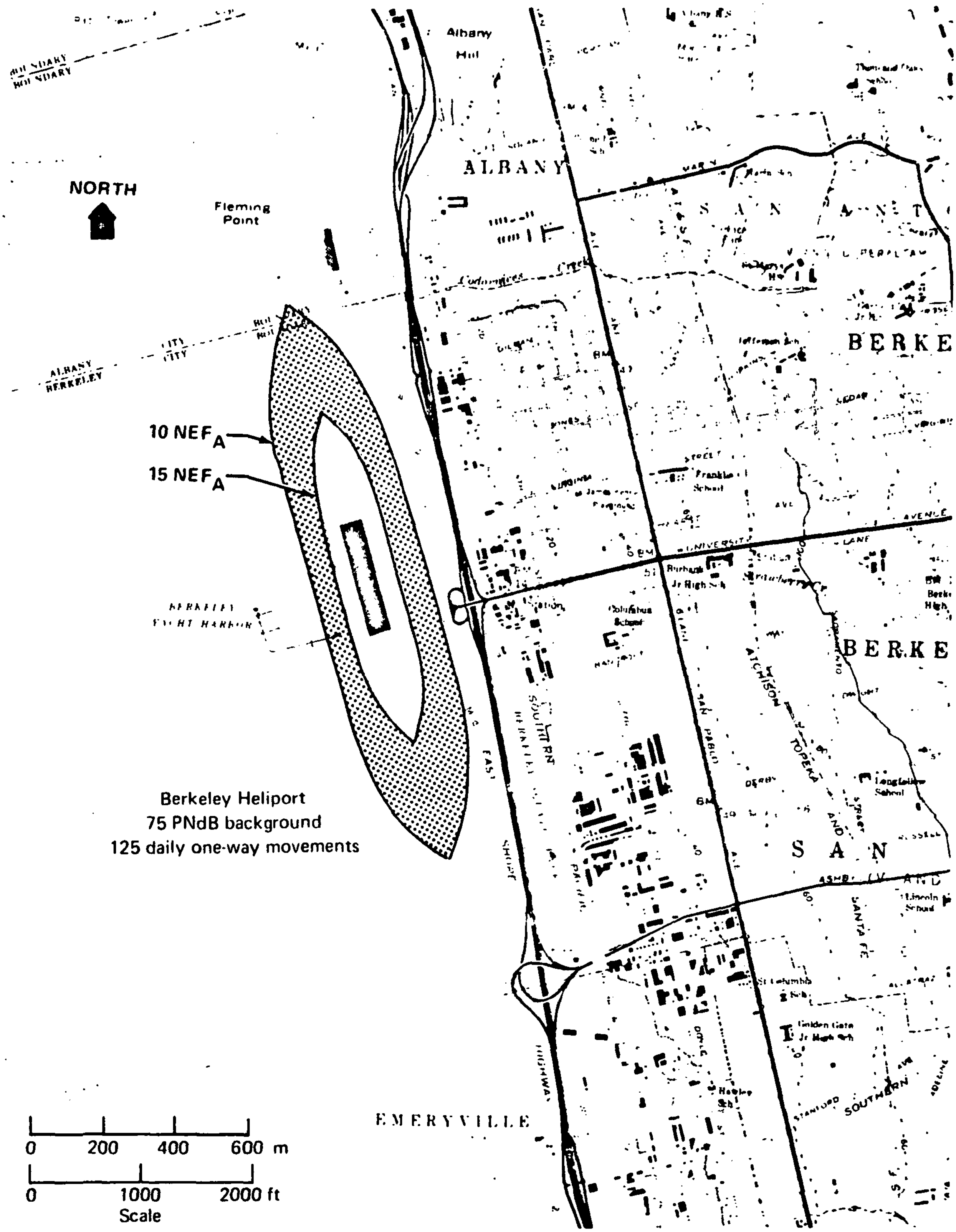


FIGURE 8-7.–COMMUNITY NOISE CONTOUR–STOL AT BERKELEY HELIPORT

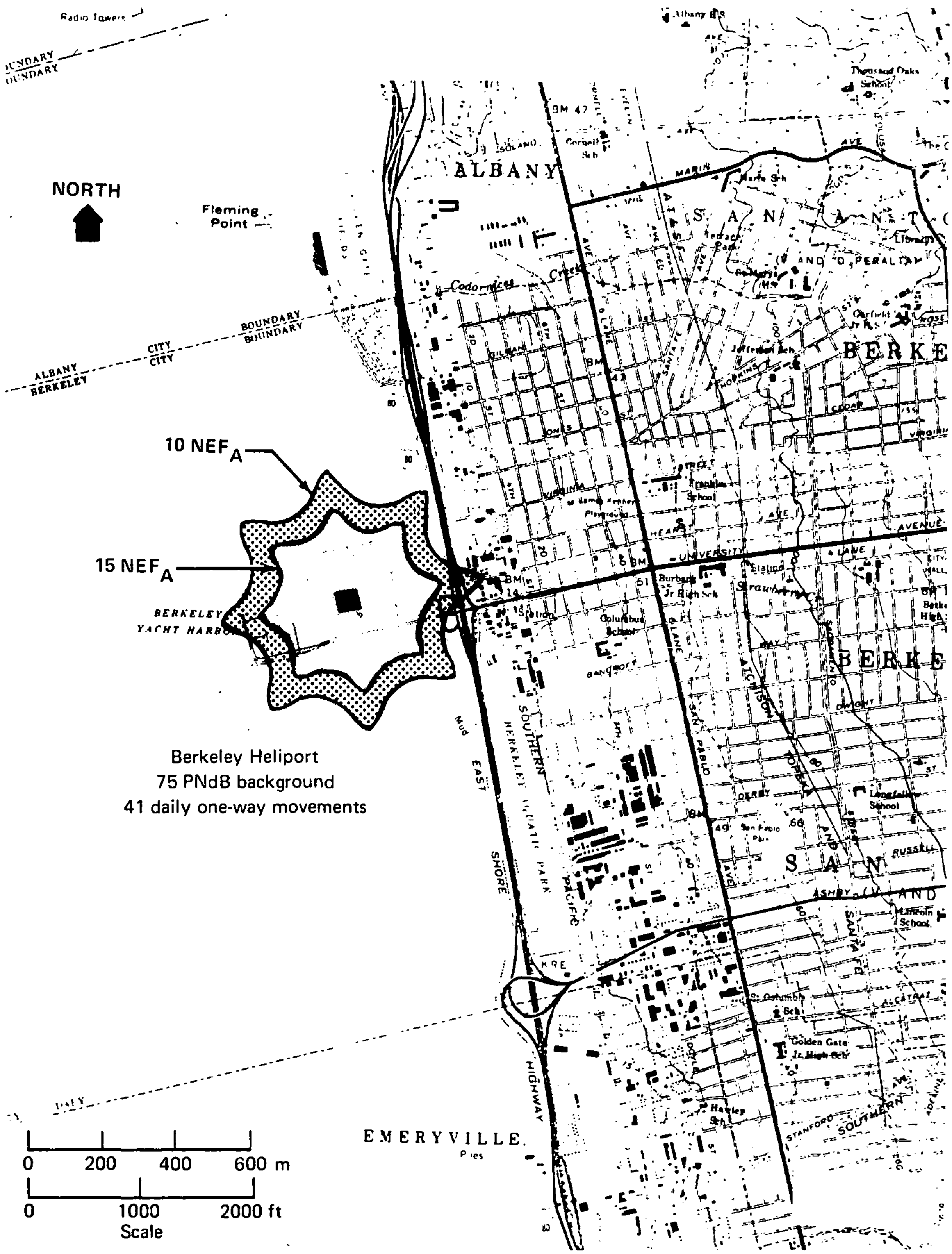


FIGURE 8-8.–COMMUNITY NOISE CONTOUR–HELICOPTER AT BERKELEY HELIPORT

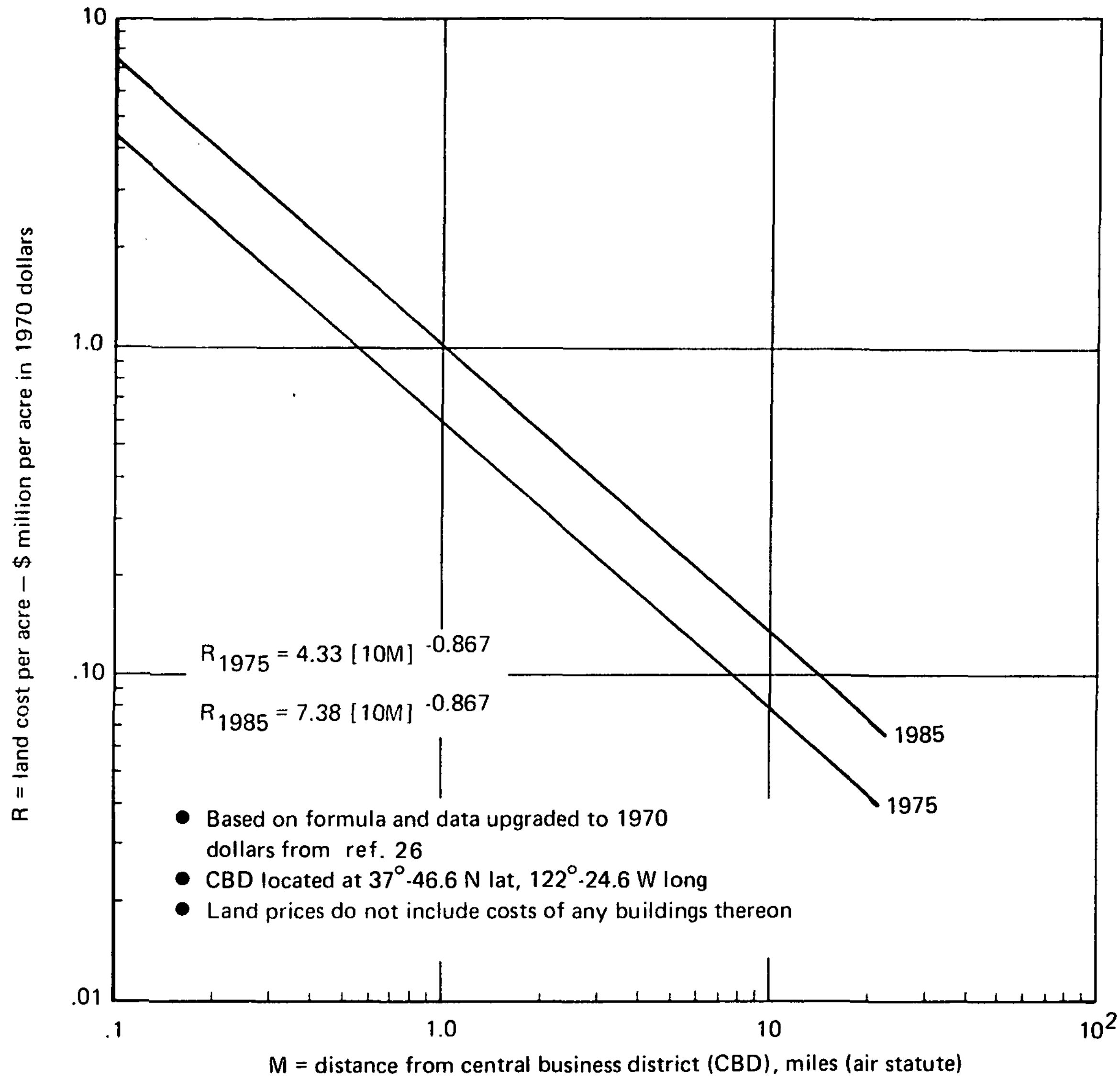


FIGURE 8-9.—SAN FRANCISCO BAY AREA LAND COSTS

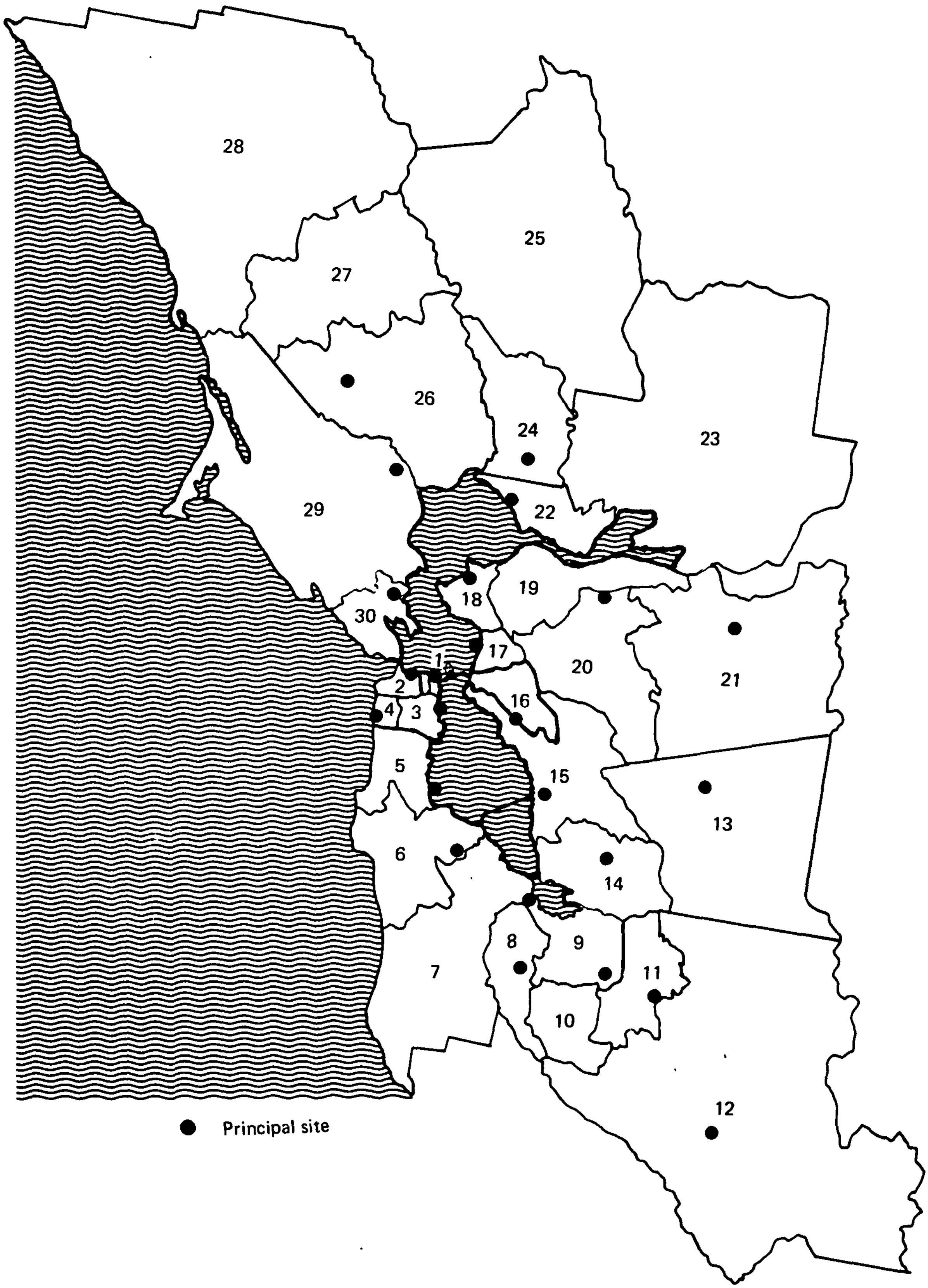


FIGURE 8-10.—1980 STOLPORT SITE SELECTIONS

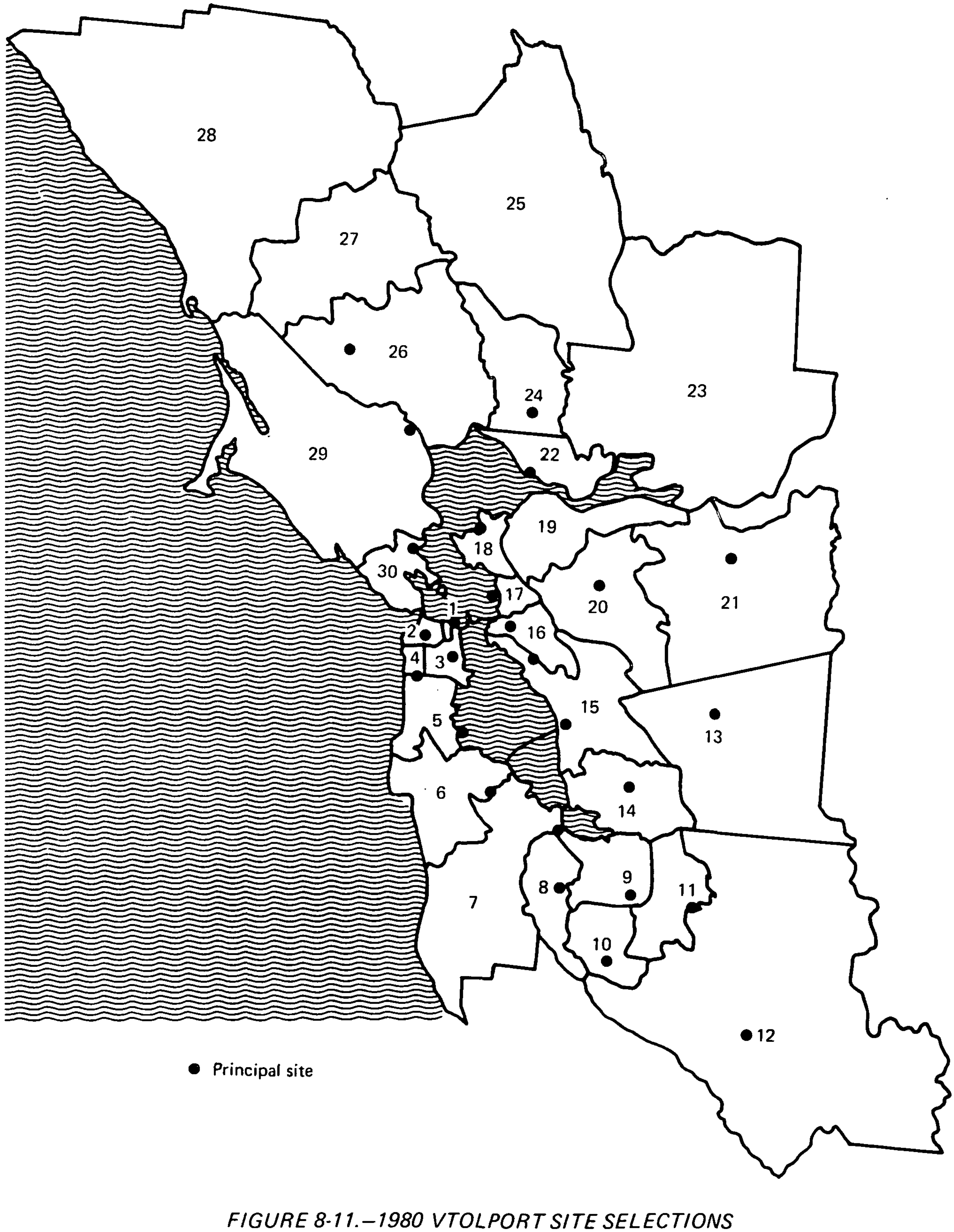


FIGURE 8-11.—1980 VTOLPORT SITE SELECTIONS

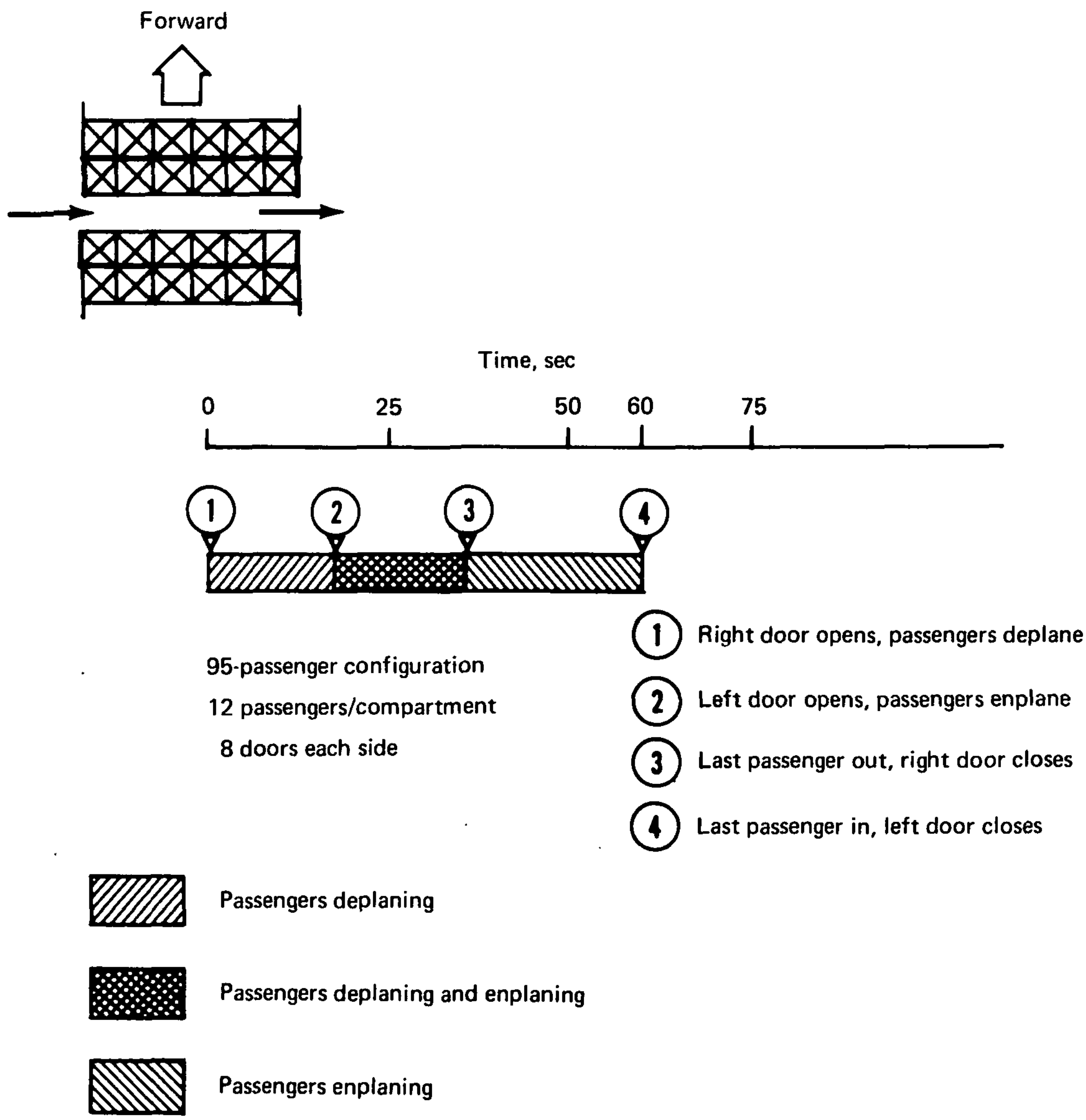
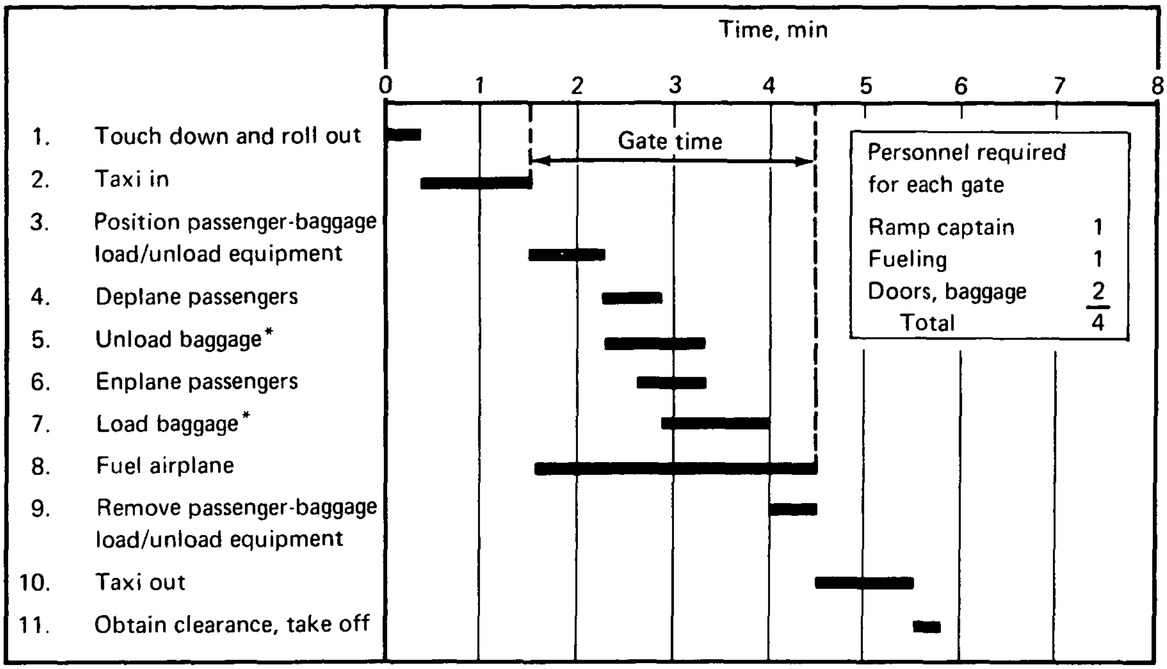


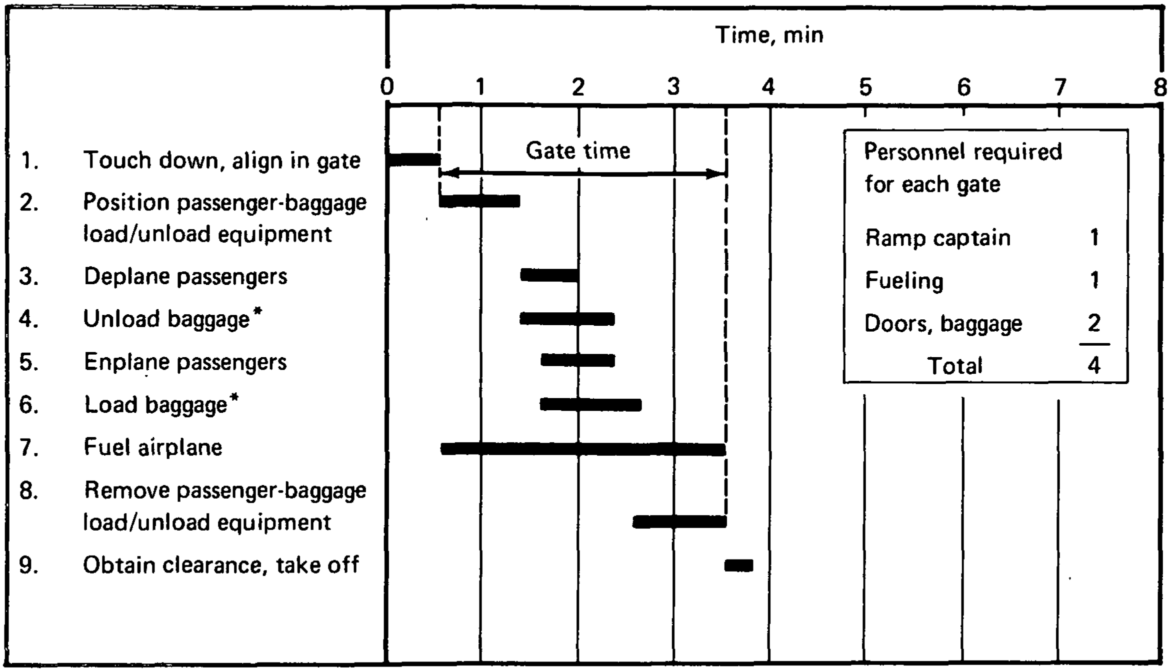
FIGURE 8-12.—PASSENGER FLOW



*To or from hub airport STOLport only

- 100-passenger STOL
- Engines not stopped
- No "walk around" inspection
- Based on layout of rooftop STOLport
- 3000 lb (1360 kg) fuel added via semiautomatic fueling connection located on fuselage underbody

FIGURE 8-13.–STOL GROUND OPERATIONS



*To or from Hub Airport VTOLport only

- 100-passenger VTOL
- Engines not stopped
- No "walk around" inspection
- VTOL lands and takes off at gate position
- Passenger-baggage load/unload equipment elevates from flush with gate slab to alongside each side of VTOL
- 3000 lb (1360 kg) fuel added via semiautomatic fueling connection located on fuselage underbody

FIGURE 8-14.—VTOL GROUND OPERATIONS

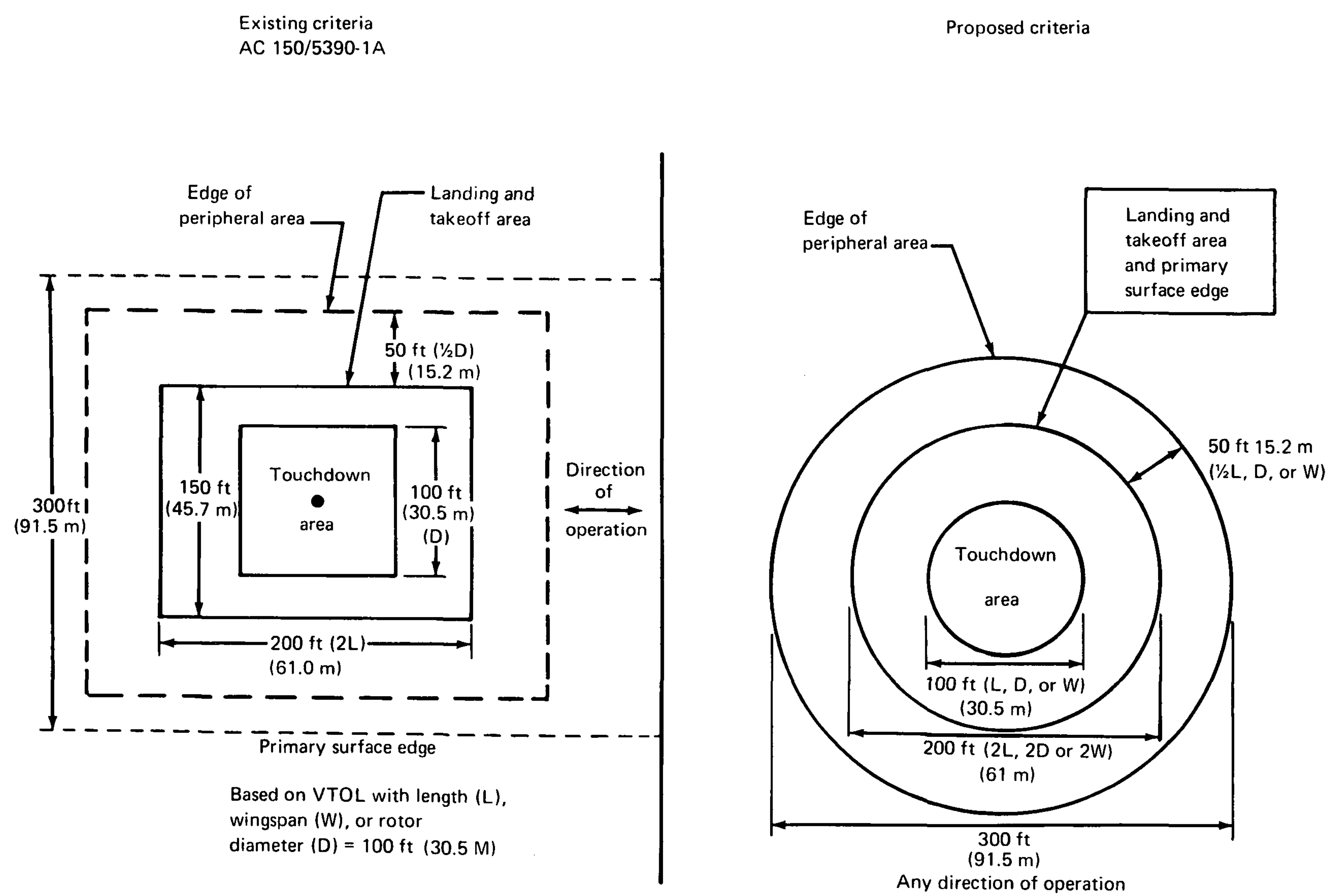


FIGURE 8-15.—VTOLPORT DESIGN CRITERIA

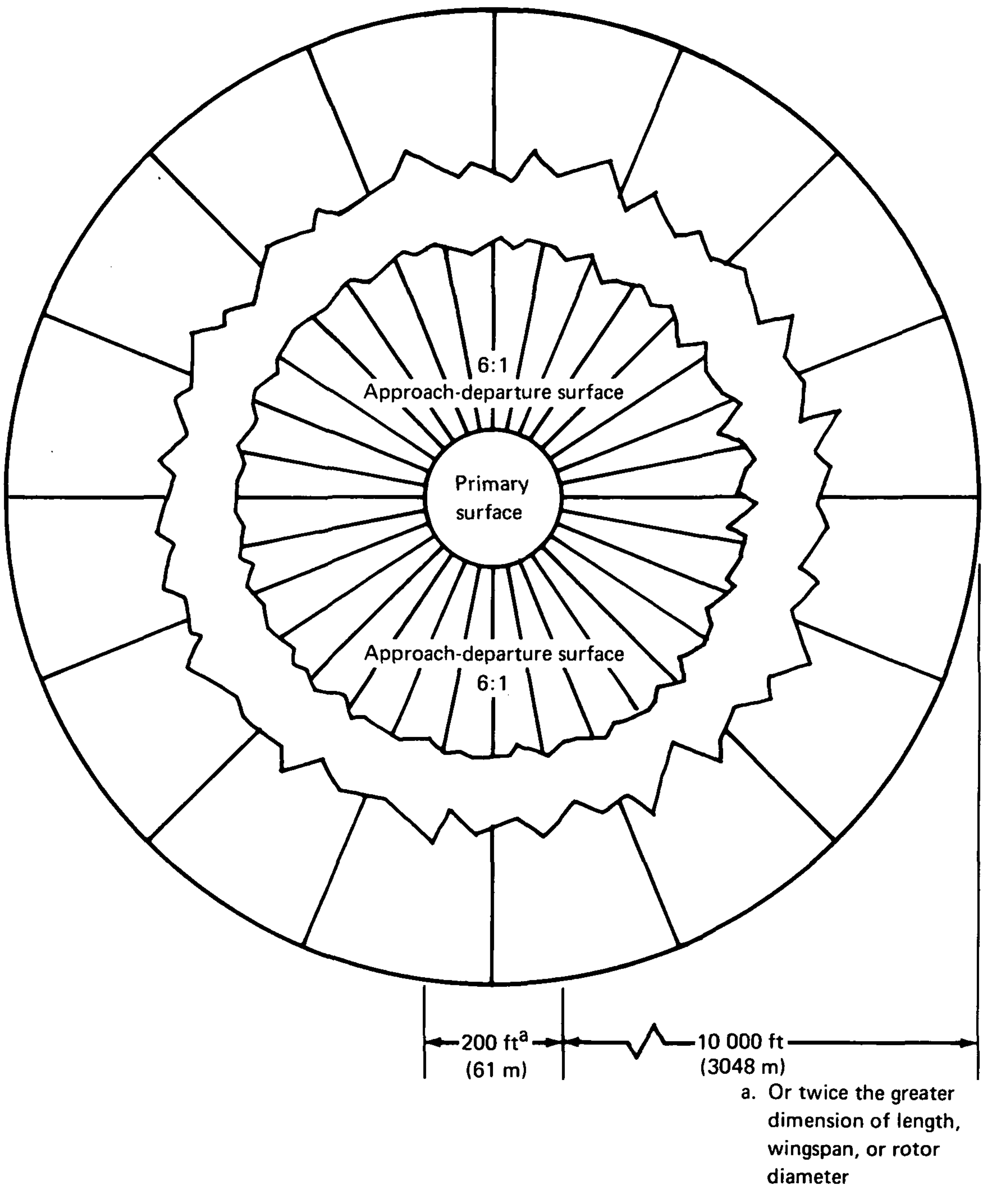


FIGURE 8-16.—PROPOSED VTOLPORT PRECISION IFR OBSTRUCTION CLEARANCE SURFACES

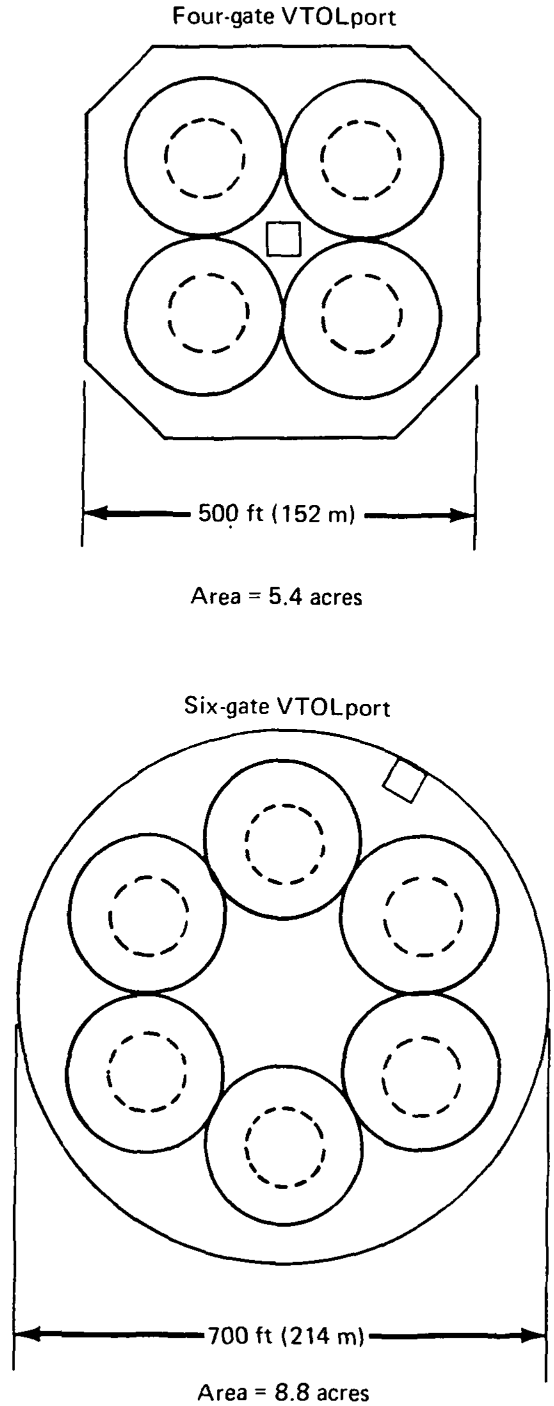


FIGURE 8-17.–POSSIBLE VTOLPORT LAYOUTS

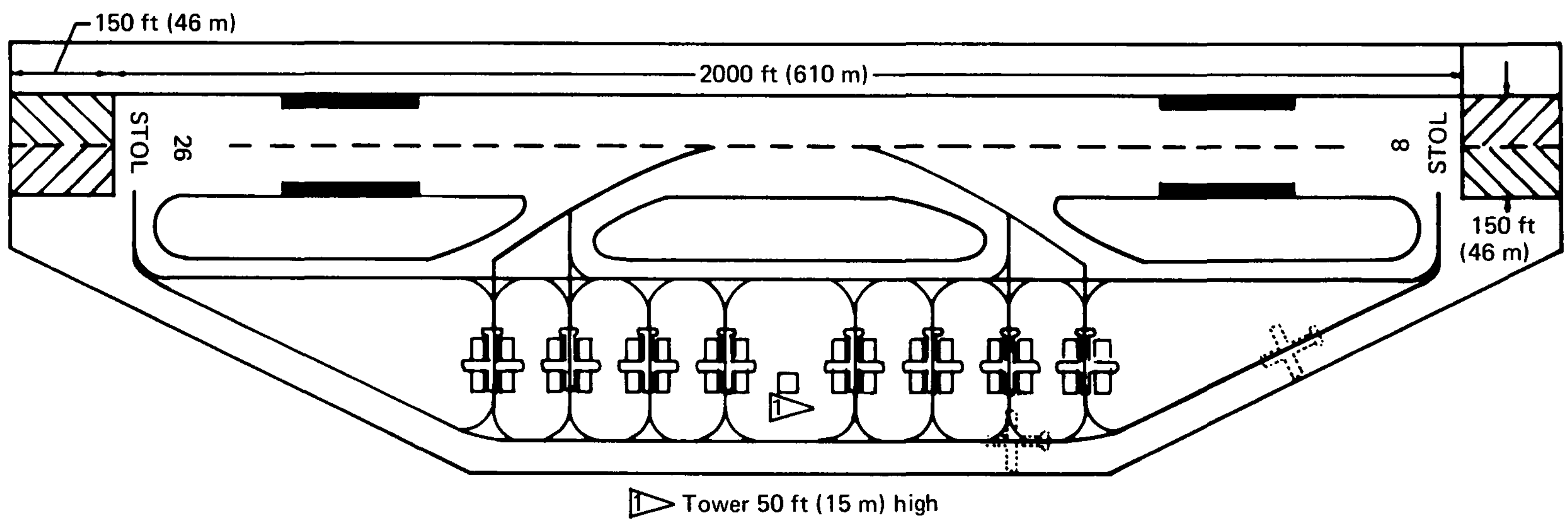


FIGURE 8-18.–ROOFTOP STOLPORT FOR INTRAURBAN SYSTEM REQUIRING 29 ACRES LAND

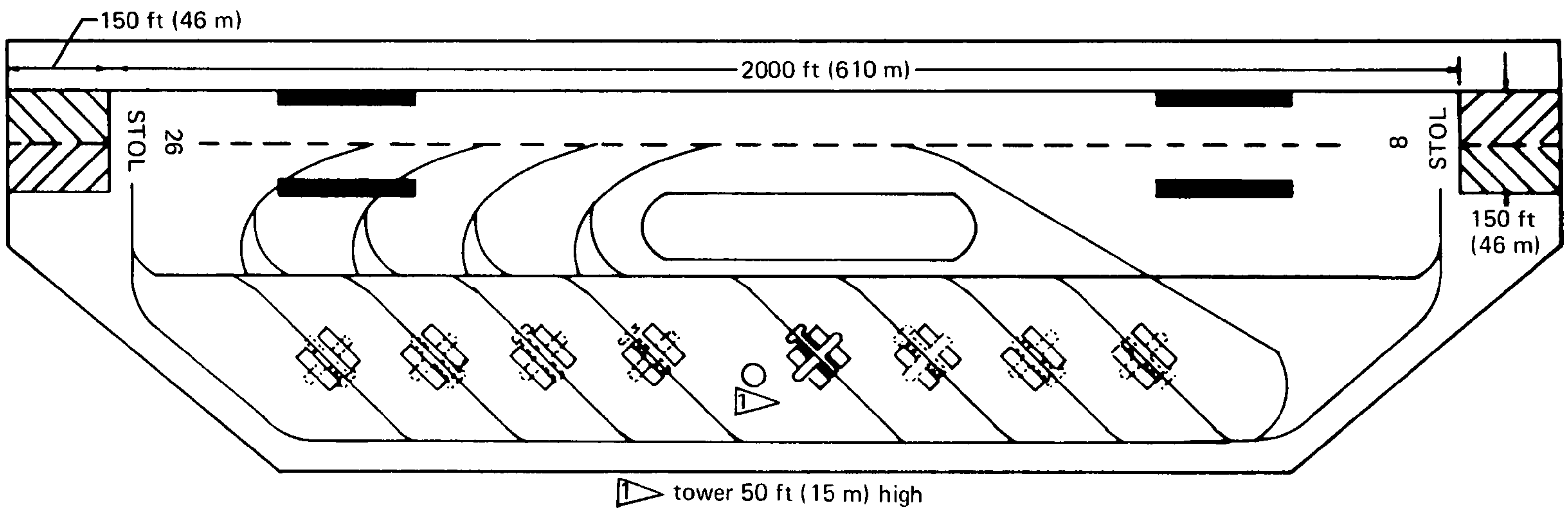


FIGURE 8-19.—ROOFTOP STOLPORT FOR INTRAURBAN SYSTEM REQUIRING 30.5 ACRES LAND

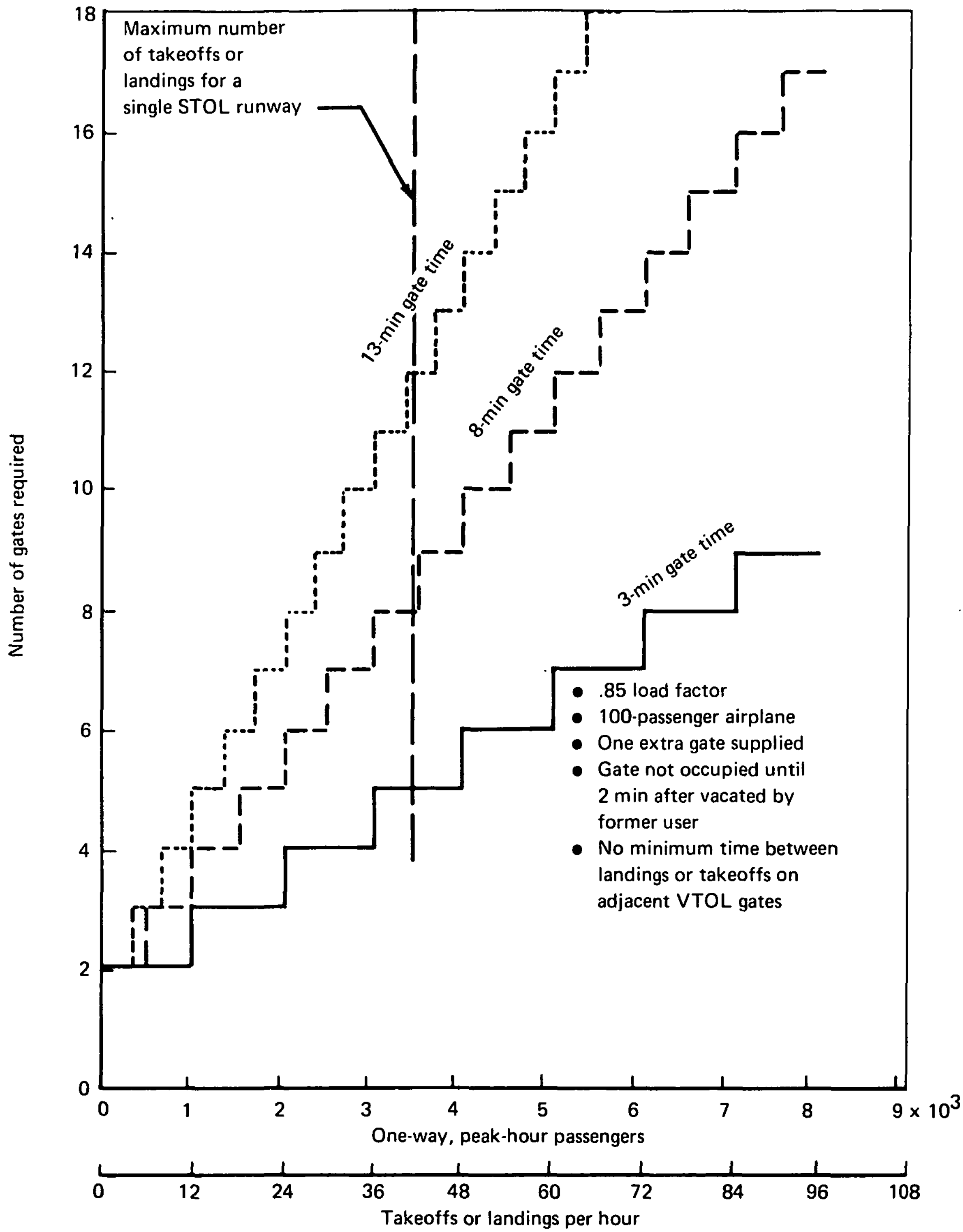


FIGURE 8-20.–STOLPORT AND VTOLPORT GATE REQUIREMENTS

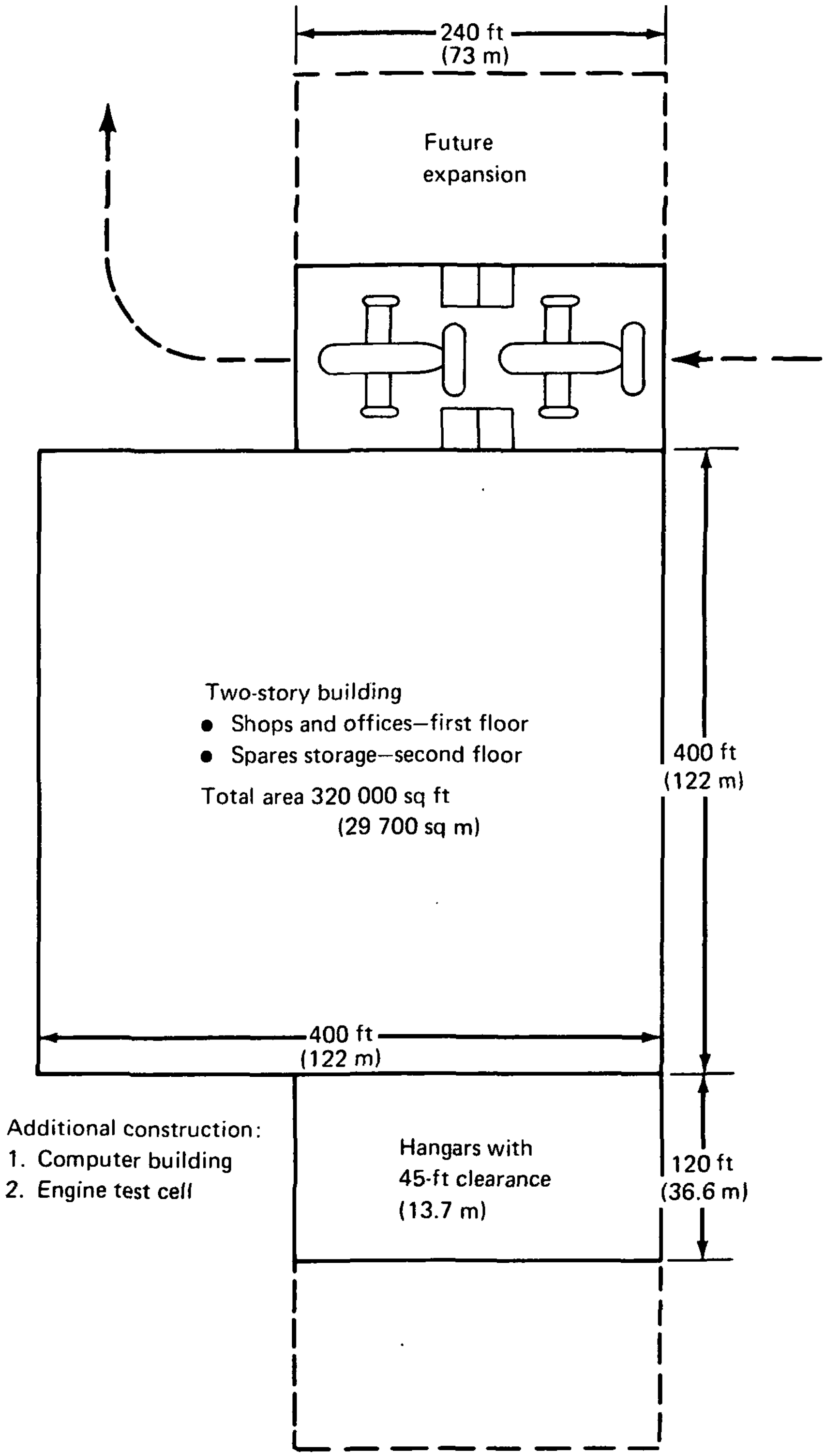


FIGURE 8-21.—CENTRAL CONTROL BASE

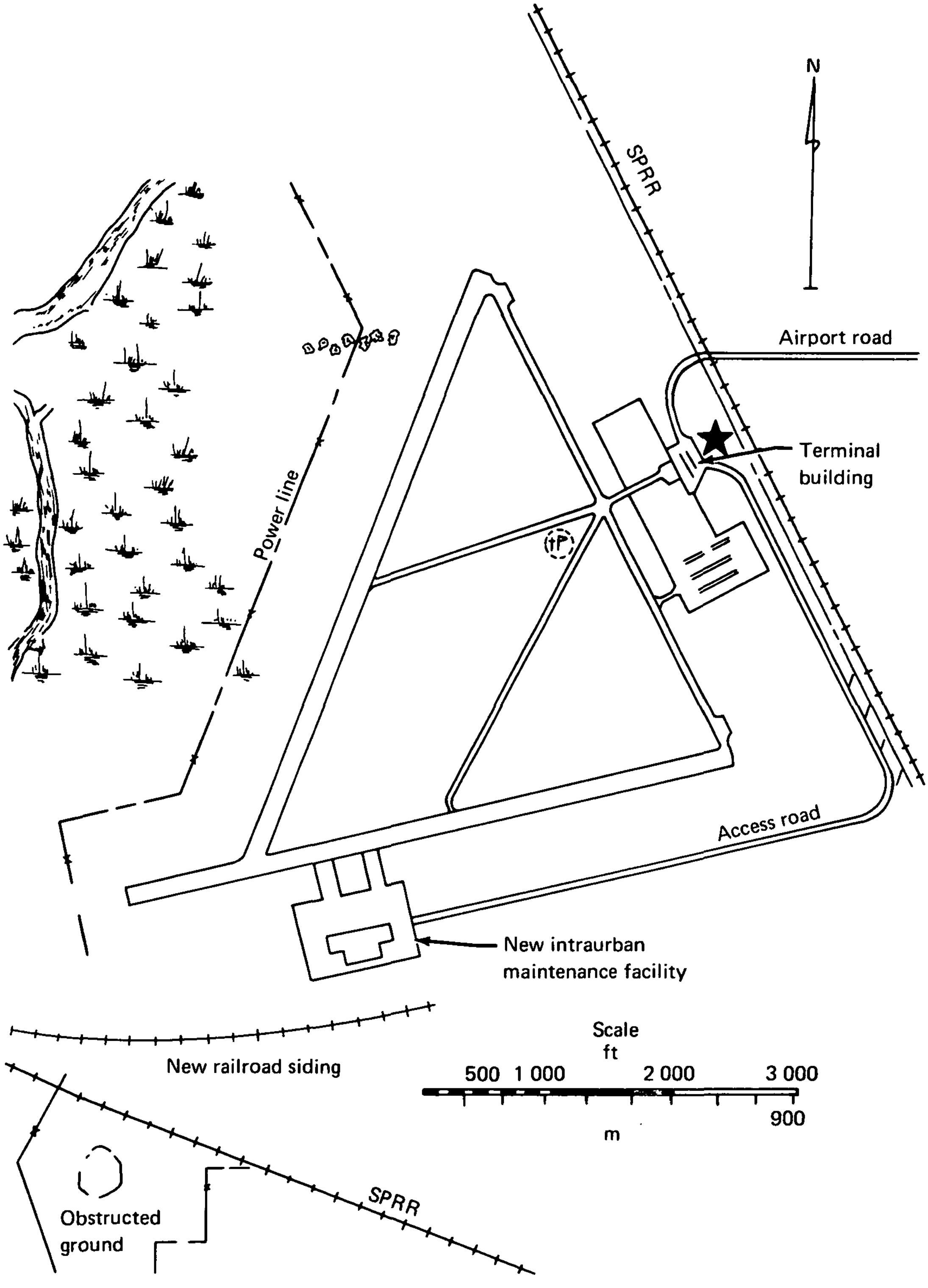


FIGURE 8-22.–NAPA COUNTY AIRPORT PROPOSED INTRAURBAN MAINTENANCE FACILITY

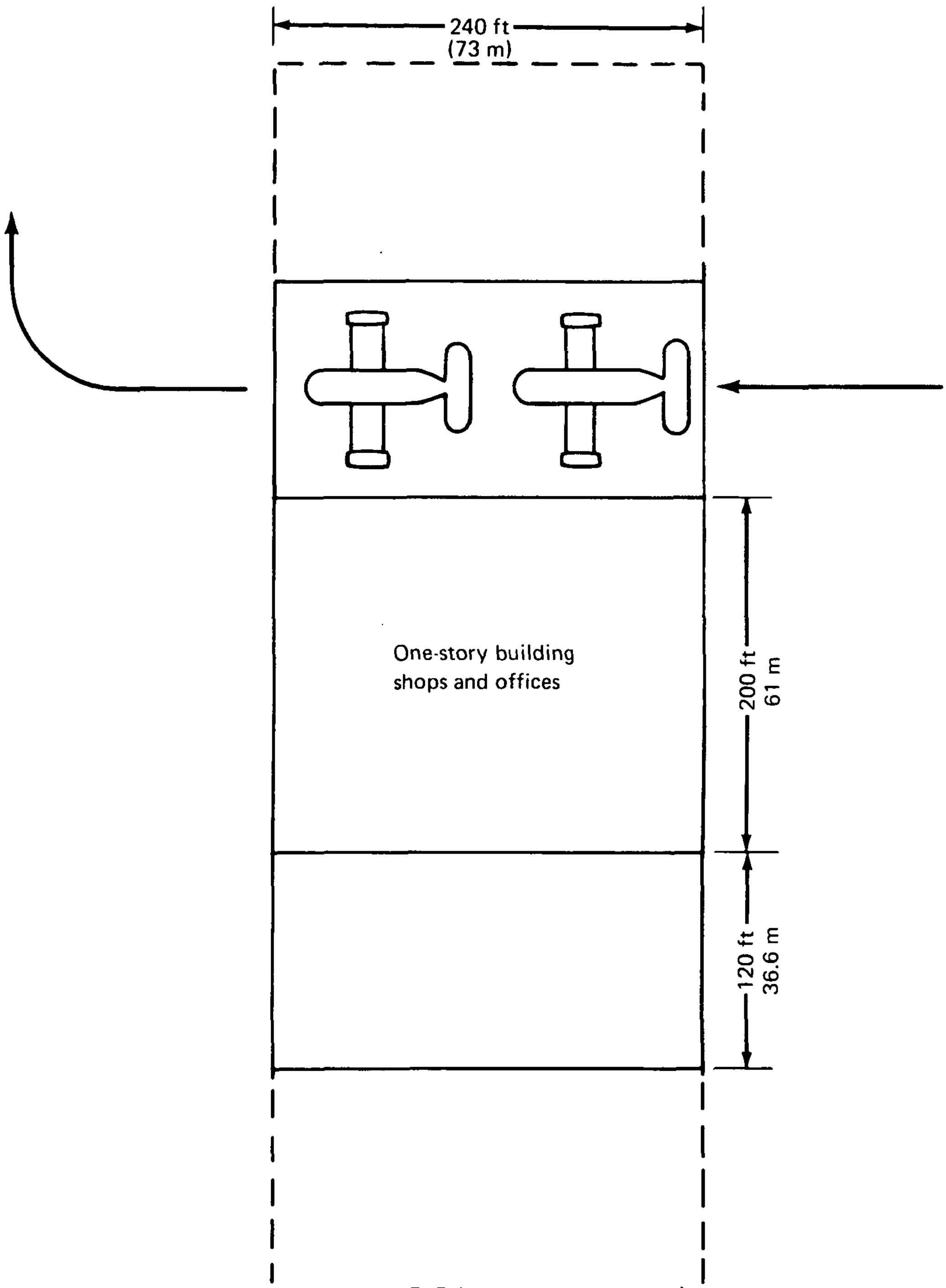


FIGURE 8-23.—SATELLITE BASE

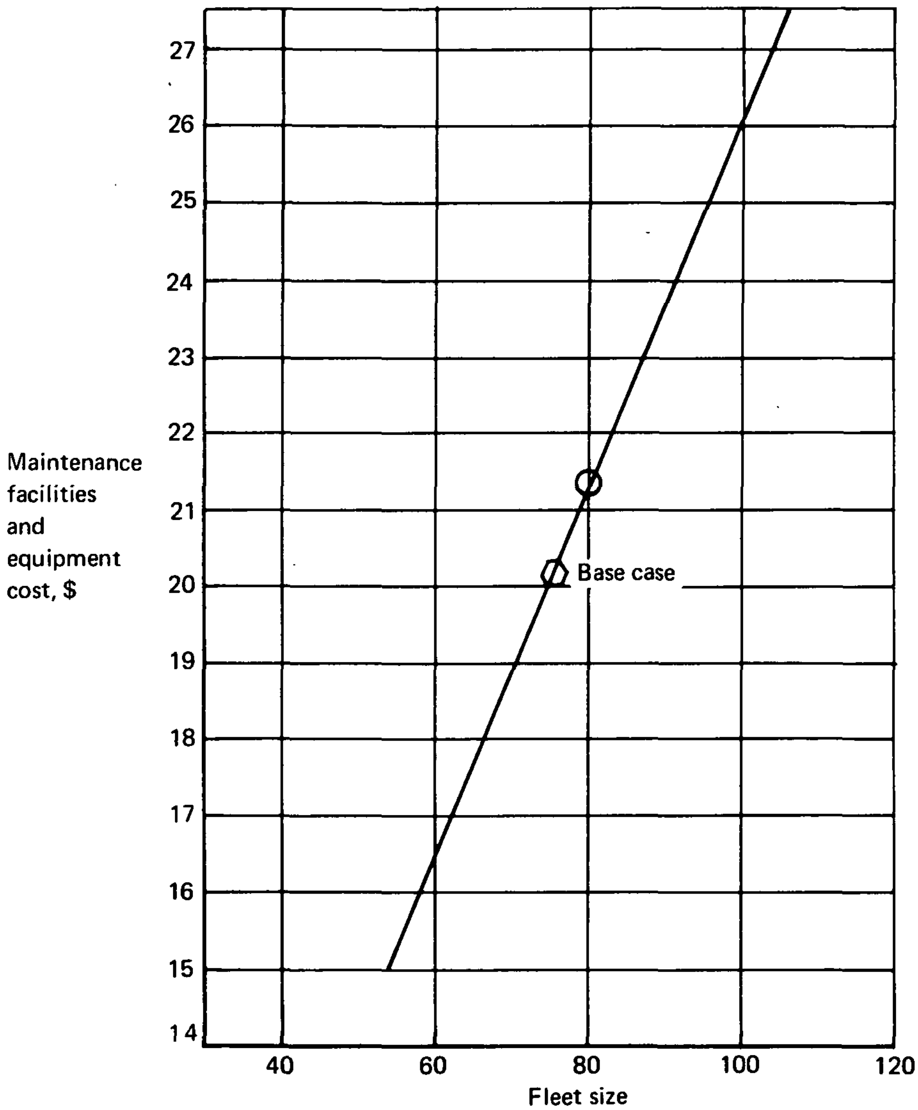


FIGURE 8-24.—MAINTENANCE FACILITIES COST

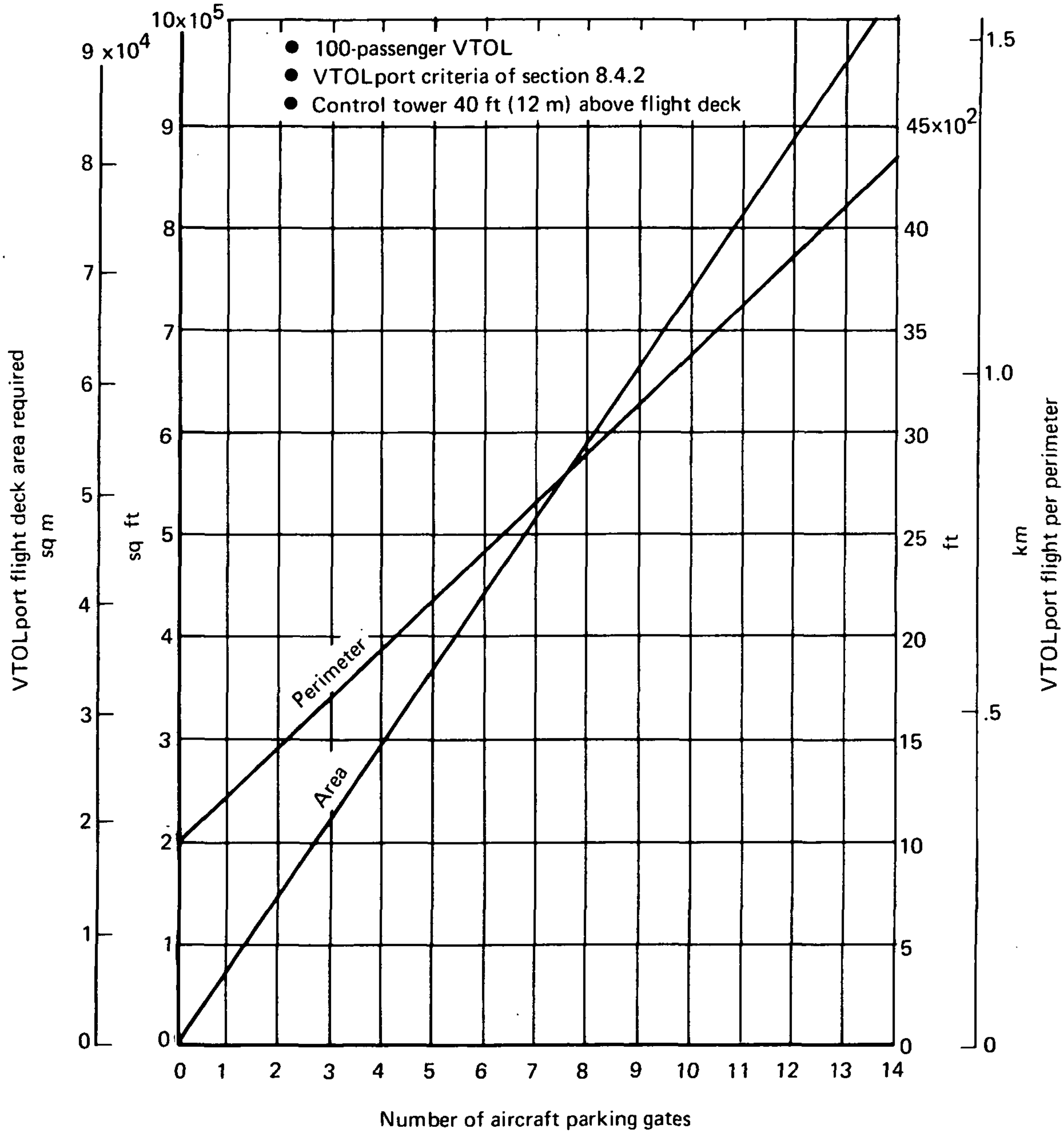


FIGURE 8-25. VTOLPORT FLIGHT DECK REQUIRED AREA AND PERIMETER

9.0 AIR TRAFFIC CONTROL ANALYSIS

The air traffic control (ATC) analysis is an examination of the environment in which the intraurban transportation system must operate in both the near term and far term (1975 and 1985). This environment determination is critical to the establishment of the economic system viability. Under current operating rules (relating to approach spacing during final approach), the expected runway acceptance rate is only 28 landings per hour. Obviously, many proposed STOLport locations will not produce a demand equal to this. Nevertheless, the focal STOLport locations considered in this study will require a runway operation rate capability greater than this value. The intent in this analysis is to demonstrate how this can be accomplished.

9.1 OPERATIONS OF EXISTING CTOLPORTS

The ATC environment analysis is based on a study of the existing use of the airspace. Almost all of today's operations are made by CTOLcraft operating in a manually controlled ATC system. The primary responsibility for control of the IFR traffic in the area studied rests with the Oakland Air Route Traffic Control Center (ARTCC), and the Oakland Terminal Radar Control (TRACON). The ARTCC controls the en route traffic while the TRACON controls the terminal-area traffic. The IFR CTOL traffic flows along routes called STAR and SID (standard arrival routes and standard instrument departures). Figure 9-1 illustrates the traffic flow in and out of the three major IFR CTOL terminals: San Francisco, Oakland, and San Jose.

The analysis of the operations of existing CTOL operations reveals the airspace volume that today is committed to approach and departure routings to the CTOLports in the Bay region. Those routes generally avoid passing over the CBD of San Francisco and cross over densely populated residential areas at altitudes higher than those projected for use in the intraurban STOL system. The analysis shows that airspace not currently committed to IFR CTOL use exists for dedication to intraurban STOL use.

9.2 POSTULATED ATC SYSTEM FOR 1975

Since a new control system procedure is required to support an improved (increased) STOL runway operations rate, the 1975 system is a natural starting place. The STOL intraurban system will operate within dedicated en route airspace and from STOLport runways exclusively used by the STOL fleet. This will provide the independent environment necessary for the easy introduction of a new ATC system scheme.

The intraurban STOL ATC system postulated for 1975 will be based on strategic control of time-synchronized aircraft operating within a closed system. The current and projected U.S. national airspace system (NAS) operates under tactical control where most traffic planning is carried on a rather short-term basis with conflicts resolved as they start to occur. The North Atlantic ATC system, on the other hand, is an example of strategic

control where long-term accurate planning is used with each flight to avoid conflict situations with all other strategically controlled flights.

The tactical system is used in domestic airspace because the navigation and surveillance environments allow the use of smaller spacings (higher traffic densities) and the complexity of the traffic is beyond the capability to manually plan strategic flights. With advances in airborne avionics and ground-based equipment, strategic control in the STOL environment is possible. Large ground-based computers can accomplish the long-term flight planning required for strategic control, while advanced precision navigation and four-dimensional guidance equipment can ensure aircraft position as a function of time with an accuracy that is small compared to the desired separation between aircraft.

The use of strategic control moves the major portion of the ATC workload from real-time during the flight to fast-time before the flight. The avoidance of conflicts minimizes the need for communication thereby reducing this workload. Thus, the controllers real-time task becomes one of monitoring flight progress and since the desired paths are known as a function of time, the details of progress monitoring are an easy task for a computer.

Strategic control also minimizes STOL airspace requirements since large volumes need not be set aside for maneuvering to resolve conflicts or vectoring to achieve desired spacing.

Preliminary analyses indicate that strategic control, when applied to approach operations, will allow an increase in runway acceptance rate because (1) the control and communication workload is no longer the constraining factor and (2) longitudinal spacing can be controlled more precisely than with automated vectoring-type systems (e.g., CAAS, FASA, DICE, etc.).

Since the advanced navigation and guidance equipment required for strategic control is planned for CTOL commercial transports in the near future (primarily for reasons of safety and improved pilot operations), it seems that this method of control is inevitable.

There are extensive data on the performance of tactical control. However, only a limited amount of data of similar quality are available on strategic control. Therefore, an effort is required to develop data on airplane performance under strategic control, to analyze the performance of the strategic control concept considering the constraints due to STOL traffic demands and weather, and to determine the required system development effort.

The time-synchronized STOLcraft will fly routes defined by a series of waypoints, altitudes, and time to pass each waypoint. ATC will assign waypoint times to each flight that are later than those assigned the preceding flight by some desired time space. The STOLcraft will fly this scheduled path, making good the waypoint times with an error that is small compared with the desired time spacing. Figure 9-2 illustrates the time-synchronized concept for a flight as it nears the terminal area. In this example, the STOL will reach the initial approach fix at the assigned time, within some small error limit. Based on the earliest possible landing time, ATC would assign the next open landing slot. Then the waypoint times and path would be calculated and transmitted to the STOLcraft. Leaving the initial

approach point at T, traveling through T_2 to T_{OM} the flight would maintain its position by flying a common ground speed and approach profile with other STOL craft in the system.

A digital computer would be used to combine data from an inertial measurement unit and from VOR/DME equipment in an optimum fashion with Kalman filtering to provide continuous precise measurement of airplane position. The automatic path guidance system will control the velocity of the aircraft and cause it to make good a scheduled flightpath as received by data link. These functions are the next step beyond the area navigation, vertical guidance, and data link capabilities being installed on some aircraft today, and the same or similar equipment can be used. Figure 9-3 illustrates the aircraft system equipment requirements.

The ATC equipment being planned for implementation between now and 1980 can be used to accomplish time-synchronized approach control. NAS stage A and ARTS provide the digital processors necessary to compute the scheduled flightpaths. The improved beacon system will provide three-dimensional surveillance, while a digital data link would be used to receive data such as the planned final approach speed and to transmit the flightpath and schedule.

The performance available from precision navigation and automatic path guidance, when used for time-synchronized approach control, has been estimated. Using automatic path guidance, the outer marker can be reached within 2 sec of the assigned time. From outer marker to the threshold it is the difference in transit time errors for two successive approaches that is significant. For example, if an unkown headwind causes them all to arrive 10 sec late, this doesn't change the spacing in time. Therefore, the one airplane contribution to loss of separation between outer marker and threshold error is about 4 sec.

9.2.1 Aircraft Separation Time Analysis

Our studies of the effects of this accuracy of arrival on runway operations rates substantiate the requirement for changing the ATC control mode to raise the operation rates. One analysis considered the following:

The flightpath considered consists of the final approach from the outer marker to touchdown and the ground roll to turnoff. The STOL runway under consideration was 1500 ft (457 m) long, with a 10-kn (18.5-km/hr) turnoff speed exit at the end of the runway. A 6° glide-slope angle was assumed, the glide-slope antenna being located 300 ft (91.5 m) from the threshold. The outer marker (OM), representing the glide-slope intercept point at 1500 ft (457 m) altitude, was 2.3 nmi (4.26 km) distant from the runway threshold. The layout of the runway and approach path is shown in figure 9-4.

Figure 9-4 also shows the speed profile of a typical approach. The values for speed, time, and distance shown on the chart were derived through the use of the following considerations:

- The actual approach speed of an aircraft was assumed to be a normally distributed random variable that was a function of the assigned approach speed (equal to the

reference speed of the aircraft, V_{REF}).* For V_{REF} = 77 kn (143 km/hr), the parameters of the distribution were as follows:

Mean	$\mu_{V_{APP}}$ = 82.3 kn (152.5 km/hr)
Standard deviation	$\sigma_{V_{APP}}$ = 5.04 kn (9.3 km/hr)

- The touchdown speed was also assumed to be a normally distributed random variable whose parameters, based on V_{REF} = 77 kn (143 km / hr), are shown below:

Mean	$\mu_{V_{TD}} = V_{REF}$ = 77 kn (143 km/hr)
Standard deviation	$\sigma_{V_{TD}}$ = 4.15 kn (7.7 km/hr)

- The difference between approach speed and touchdown speed was bled off during flare, which was started at the threshold.

- Touchdown dispersal was assumed to be a normally distributed random variable.

Mean	μ_{TD} = 400 ft (122 m)
Standard deviation	σ_{TD} = 50 ft (15 m)

- Deceleration due to braking was assumed to be at a constant rate of 10 ft/sec^2 (3 m/sec^2) (mean) with a standard deviation of 0.7 ft/sec^2 (0.21 m/sec^2). Slowdown to turnoff speed (10 kn–18.5 km/hr) was accomplished in two stages:

  – Aircraft was decelerated until a speed of 50 fps (15.2 m/sec) ($\approx$ 30 kn–55 km/hr) was reached.

  – Aircraft coasted at this speed until a point was reached from which the aircraft could be decelerated to a speed of 10 kn (18.5 km/hr) by the time the exit was reached.

Derivation of the above values was based on statistical parameters describing the behavior of conventional jet transports on approach and landing obtained from flight tests described in references 31 and 32. These operational parameters were chosen to give a worst-case description of STOL aircraft behavior, based on the assumption that the performance of the STOL aircraft under consideration can be expected to be no worse, and possibly better, than that of a conventional jet on final approach and landing.

Using the above values, the travel time from outer marker to threshold (TI) and the time from threshold to turnoff, called runway occupancy time (TRO), were determined. Values of TI and TRO for three reference speeds are tabulated in table 9-1.

*V_{REF} is defined as 1.3 times the stall speed of the aircraft for a given gross weight and flap setting.

The concept of the required separation time is illustrated in figure 9-5. Separation of aircraft on final approach must be such as to ensure that an aircraft will not reach the landing threshold before the previous aircraft has turned off the runway. The second aircraft must perform a go-around if this condition is violated.

To evaluate the extent to which aircraft performance may limit runway acceptance rate, a minimum required separation time at the outer marker was determined, while keeping the corresponding go-around rate low. In figure 9-5, the solid lines represent mean values of TI and TRO. In selecting the required separation time, 3σ values of TI and TRO were used to ensure that go-arounds occur less than 0.01% of the time.

The separation times shown in table 9-1 and in figure 9-5 are based on the assumption that aircraft will be able to arrive at the outer marker precisely at the times required. The variation of separation times with arrival accuracies is shown in table 9-2.

Figure 9-6 shows the rate at which aircraft can be landed at a single STOL runway (runway acceptance rate—RAR) as a function of reference speed and ATC separation criteria. For example for V_{REF} = 77 kn (143 km/hr) corresponding to an approach speed of 82.3 kn (153 km/hr) and an ATC separation criteria of 1 nmi (1.85 km), the time separation is 43.1 sec. The runway acceptance rate associated with this time separation, with a zero go-around rate, is equal to 83 aircraft per hour.

Comparing figure 9-6 with the values of required separation time shown in tables 9-1 and 9-2, it can be seen that, for V_{REF} = 77 kn (143 km/hr) and standard deviation of arrival time accuracy at the OM less than 4 sec, the runway acceptance rate depends only on the selected separation criteria until the ATC longitudinal separation standard falls below 1 nmi.

If the standard deviation of arrival accuracy at the OM is raised to 4 sec, the required separation time of 47.52 sec (from table 9-2) exceeds the available time separation of 43.1 sec at 1 nmi (1.85 km) longitudinal separation (for a go-around rate of less than 0.01%). However, if the go-around rate is allowed to increase to 0.2% of the runway acceptance rate, then the required separation time drops to 38.0 sec and the runway acceptance rate is still ATC separation limited at longitudinal separations of 1 nmi or greater.

9.2.2 Conclusions

From the above analysis, it can be concluded that the acceptance rate of a single STOL runway is limited by ATC separation requirements, not by aircraft performance characteristics or runway geometry, for separations 1 nmi or greater.

At a uniform assigned approach speed (V_{REF}) of 77 kn (143 km/hr) and a 1-nmi (1.85 km) arrival/arrival separation rule at the OM, the expected RAR is equal to 83 aircraft per hour with a go-around rate less than 0.01% of RAR, so long as the standard deviation of arrival times at the OM is less than 4 sec. If ATC separation less than 1 nmi can be realized, correspondingly higher runway acceptance rates, while keeping the go-around rate to less than 0.01%, can be achieved by introducing additional runway exits with higher turnoff speeds.

9.3 SUCCESSIVE ARRIVALS AND ARRIVAL/DEPARTURES

The present rule requires that a departing aircraft be separated from an arriving aircraft on final approach by a minimum of 2 nmi (3.70 km) if separation will increase to a minimum of 3 nmi (5.55 km) within 1 min after takeoff.

This rule serves two purposes: one, to ensure that the departing aircraft has left the runway before the arrival reaches the threshold, and two, to ensure adequate separation of the two aircraft in case the arriving aircraft had to perform a go-around.

The STOL runway under consideration below is the same as described in the previous section and illustrated in figure 9-4. The go-around (missed approach) procedure used in the following discussion consisted of a climb to 1500 ft (457 m) followed by a 180° climbing turn to 2500 ft (762 m).

Figures 9-7 and 9-8 show the altitude and distance versus time profiles, respectively, of alternating arrivals and departures operating under today's rules of 3 nmi (5.55 km) minimum separation of arriving aircraft at the threshold. Departing aircraft have started their takeoff rolls as soon as the previous arrivals have turned off the runway.

As shown on figure 9-8, the 2-nmi (3.70-km) separation requirement at the threshold between departure 1 and arrival 1 is met, and 60 sec after takeoff, at 73 sec on figure 9-8, the separation goes to 2.92 nmi (5.41 km). If arrival 1 initiates a go-around when at 500 ft (152 m) altitude (fig. 9-7), adequate horizontal and vertical separation exists between the two aircraft at all times.

Hence, it seems that if arriving aircraft, all having a common V_{REF} of 77 kn (143 km/hr), are making approaches to the described STOL runway under the present 3-nmi (5.55 km) separation rule, a departure can be inserted between each two arrivals while complying with the departure/arrival separation requirement. The runway operations rate (ROR) can thus be increased to twice the RAR (see fig. 9-6). Therefore,

ROR = 2 RAR = 2(27.5) = 55 aircraft per hour

(for V_{APP} = 82.3 kn (153 km/hr) corresponding to V_{REF} = 77 kn) (143 km/hr)

Figures 9-9 to 9-12, inclusive, show the altitude and distance versus time profiles for arrival/arrival separations of 2 and 1.5 nmi (3.7 and 2.8 km). The basic safety criterion of no two aircraft on the runway at the same time was not violated for these separation standards. However, the 2-nmi (3.7-km) departure/arrival separation requirements must be relaxed before arrivals and departures can be alternated at these reduced separation distances. In addition, it would have to be shown that ATC control loop accuracy has been sufficiently improved to enable the safe handling of the reduced separation of a departing aircraft and an arriving aircraft resulting from the latter performing a missed approach, as shown in figs. 9-10 and 9-12.

If the reduced arrival/arrival separations are found feasible, the following operations rates can be attained on a single STOL runway when arrivals and departures are alternated:

Separation Standard	ROR
2 nmi (3.7 km)	82 aircraft per hour
1.5 nmi (2.8 km)	110 aircraft per hour

(for a common V_{REF} 77 kn (143 km/hr), corresponding to a mean V_{APP} of 82.3 kn–153 km/hr)

Figures 9-13 and 9-14 show the altitude and distance versus time profiles, respectively, of mixed arrivals and departures operating under a 1-nmi (1.85 km) arrival/arrival separation rule. As can be seen on the diagrams, arriving aircraft cross the threshold before the departing aircraft leave the runway, hence, violating the safety criterion of no two aircraft on the runway at the same time. If an arriving aircraft had to perform a go-around, its horizontal separation from the aircraft that just took off could be as low as 1300 ft (427 m). Therefore, to make mixed operations possible at 1 nmi (1.85 km) separation, the runway occupancy time of arrivals would have to be reduced along with increasing to a very high degree the accuracy of the ATC control loop. Operations rates of 166 aircraft per hour could be achieved.

This study has shown that, under today's arrival/arrival and departure/arrival separation rules (3 nmi (5.55 km) and 2 nmi (3.7 km), respectively), a departure can be inserted between each two arrivals, giving an ROR for the STOL runway of 55 aircraft per hour.

At arrival/arrival separation standards less than 3 nmi, alternate arrivals and departures could be conducted with improved ATC control loop accuracy, and/or reduced runway occupancy time of arrivals. Runway operations rates of 110 aircraft per hour could be achieved with a 1.5-nmi (2.80-km) longitudinal separation rule and 166 aircraft per hour with a 1-nmi (1.85-km) separation rule.

9.4 POSTULATED ATC SYSTEM FOR 1985

The conceptual ATC system for 1975 described in section 9.2 only applied to the independently operated STOL intraurban system. By 1985 we can expect that this same system can be applied to both the independent STOL system and the scheduled CTOL carriers. The early application of the strategic time-synchronized ATC to STOL will have hastened its extension to the remaining airline population. Only the unequipped general aviation aircraft will fly outside the strategic time-synchronized control environment.

The independence of STOL from CTOL operations will be maintained during this time period because of the differences in aircraft dynamic handling characteristics and approach/departure speeds.

9.5 INTRAURBAN ROUTES

The en route portion of the intraurban transportation system is composed of dedicated airspace lying beneath en route airspace assigned to CTOL operations. The STOL routes are described by standard area navigation route identifiers: azimuth and range from VORs located near the routes (alternatively, these descriptors may be in latitude and longitude). Each waypoint has an assigned altitude for given directions of travel in the case of routes carrying two-way traffic or where routes cross or intersect.

Because of the short length of the en route portion of the intraurban route structure, only a small volume of airspace must be dedicated to STOL exclusive use. The volume of airspace assigned to actual approach and departure paths appears, in plan view at least, somewhat larger than the en route airspace. This is because airspace in and about each STOL airport must be available for possible approaches from more than one direction (on account of wind changes), and missed-approach/go-around procedures. The airspace assigned to each STOL airport must be identified on navigation charts. This airspace will include the areas required for approaches to both ends of all usable runways for all applicable wind conditions. In actual use, the airspace being used for any one wind direction may be much less than that shown on the charts.

9.6 AVIONICS REQUIREMENTS

As discussed in section 8.2, one key to a successful intraurban transportation system is having the ability to maintain a high runway operations rate. Table 9-3 lists the physical characteristics of a proposed avionics system that is suitable for use in a variety of aircraft that might be considered for intraurban application, is compatible with the advanced ATC system described earlier, and is capable of supporting increased operations rates.

TABLE 9-1.—TRAVEL TIMES AND RUNWAY OCCUPANCY TIMES FOR THREE REFERENCE SPEEDS

	Runway occupancy time		Approach time, TI		Required separation time
	Mean	Variance	Mean	Variance	
V_{REF}, kn (km/hr)	μ_{TRO}, sec	σ_{TRO}^2, sec^2	μ_{TI}, sec	σ_{TI}^2, sec^2	$\mu_{TRO} + 3\sigma_{TI} + 3\sqrt{\sigma_{TI}^2 + \sigma_{TRO}^2}$, sec
70 (130)	21.74	2.897	110.62	4.576	36.35
77 (143)	19.69	3.510	100.57	3.782	33.61
84 (156)	17.32	4.248	92.19	3.178	30.82

TABLE 9-2.—EFFECT OF ARRIVAL ACCURACY ON REQUIRED SEPARATION TIME

	Standard deviation of arrival times at outer marker, σ_{TOM}, sec					
V_{REF},	1	2	4	6	8	10
kn (km/hr)	Required separation time, sec					
70 (130)	37.70	40.09	49.84	60.64	71.95	93.49
77 (143)	34.88	37.20	47.52	58.34	69.69	81.29
84 (156)	32.16	35.48	44.94	55.97	67.29	78.91

TABLE 9-3.—INTRAURBAN AIRPLANE AVIONICS

Quantity per airplane	Avionics system	Weight each/total, lb	Weight each/total, kg	Volume total, ATR [a]	Power total, W
(b)	Inertial navigation system	100	45.3	---	200
(b)	Flight control computer (central data processor and automatic guidance program	30	13.6	---	100
(b)	Microwave landing system	75	34.0	1	100
1	Interphone	35	15.9	1/4	50
1	Passenger address	60	27.2	3/8	80
1	Voice recorder	20	9.1	3/8	12
2	VHF communications	20/40	9.1/18.1	1/2	100
2	VOR	12/24	5.4/10.9	1/2	30
1	ATC	14	6.3	1/4	30
2	Attitude reference	---		---	---
2	Compass	---		---	---
2	Flight director	---		---	---
1	Indicator, altimeter	---		---	---
2	Airspeed	---		---	---
1	Air data	---		---	---
1	Flight recorder	---		---	---

[a](ATR) (0.0248) = m^3
1 ATR = 1510 $in.^3$
[b]Single-thread system

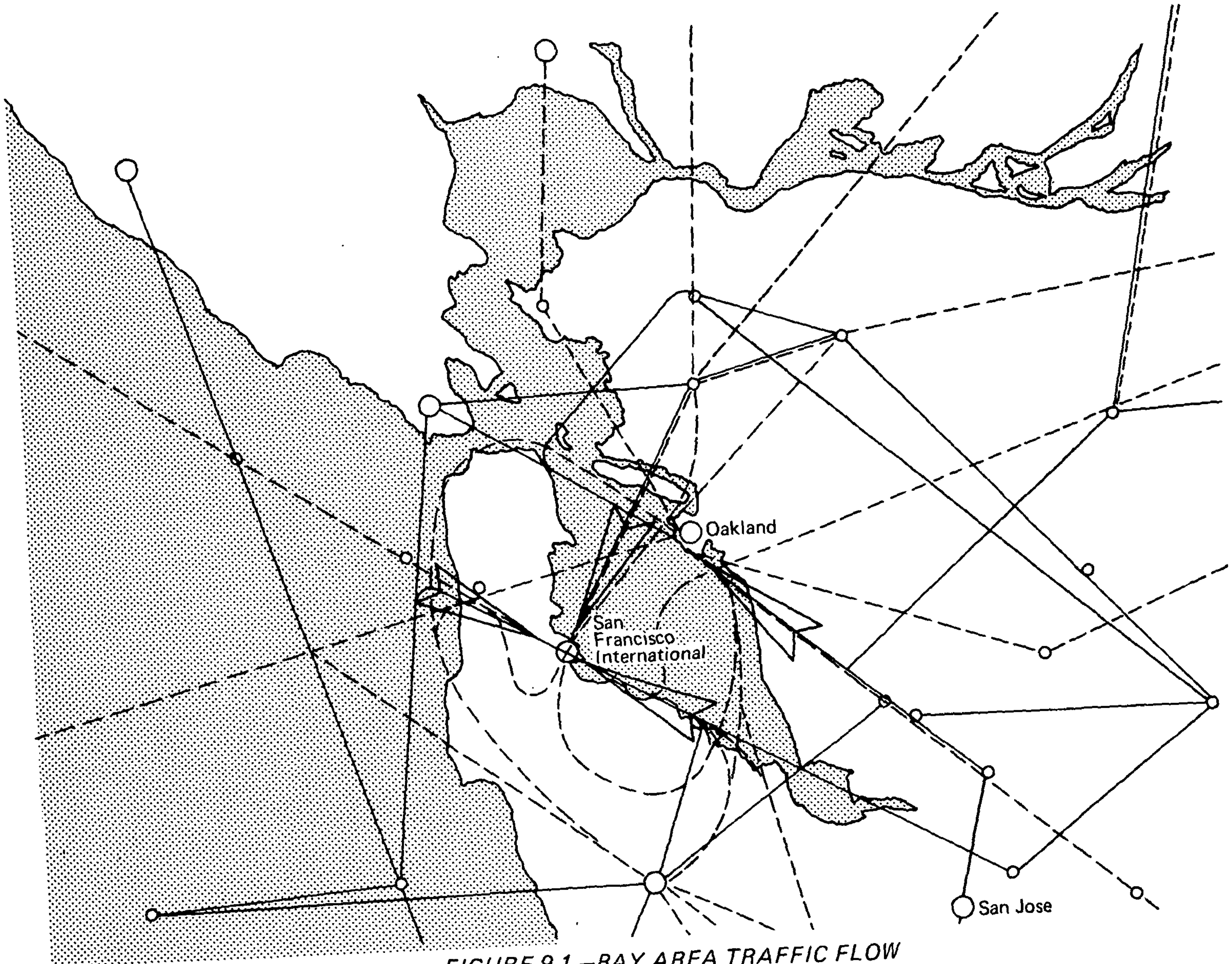


FIGURE 9-1.—BAY AREA TRAFFIC FLOW

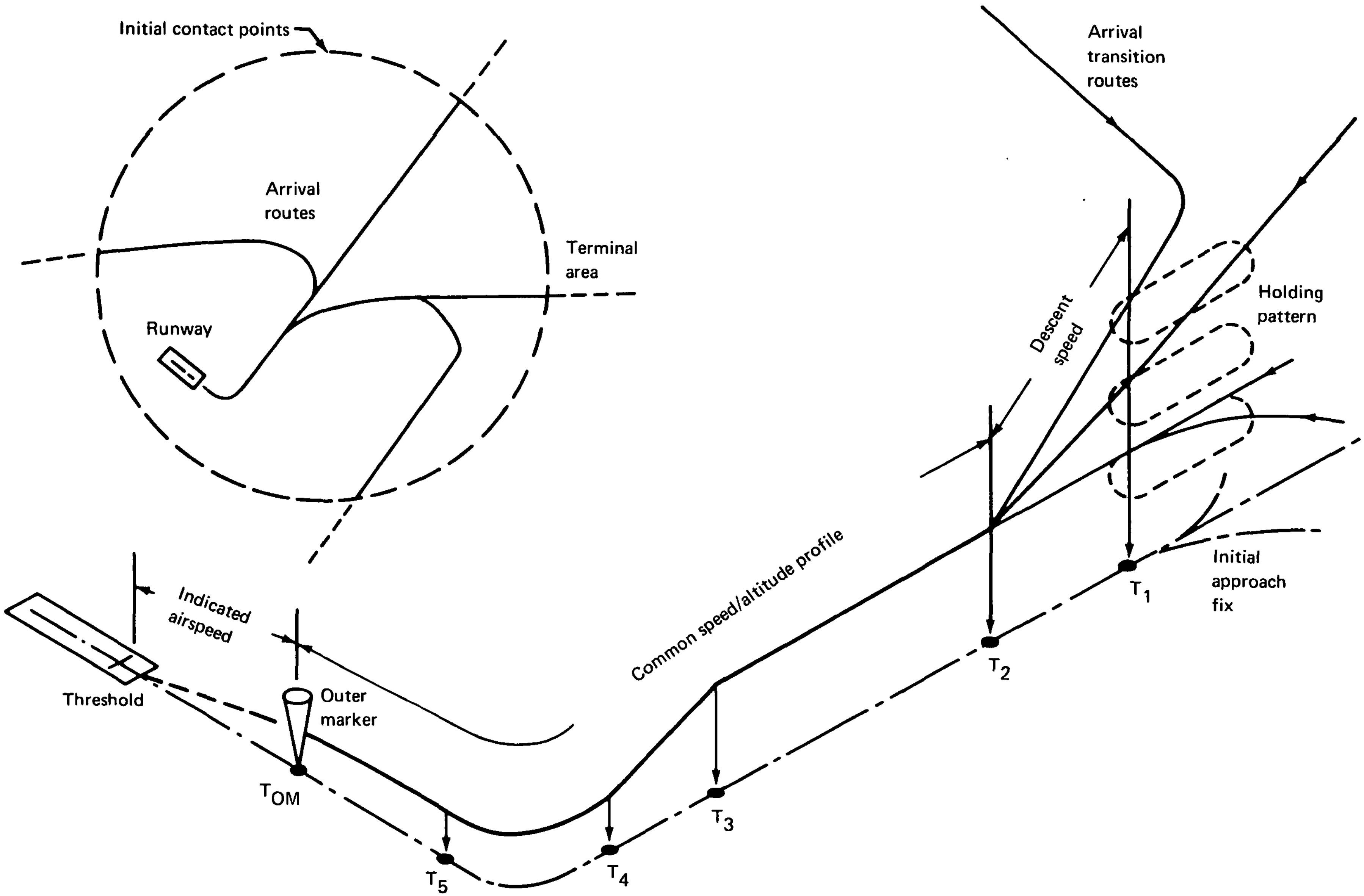


FIGURE 9-2.–TIME-SYNCHRONIZED APPROACH CONTROL CONCEPT

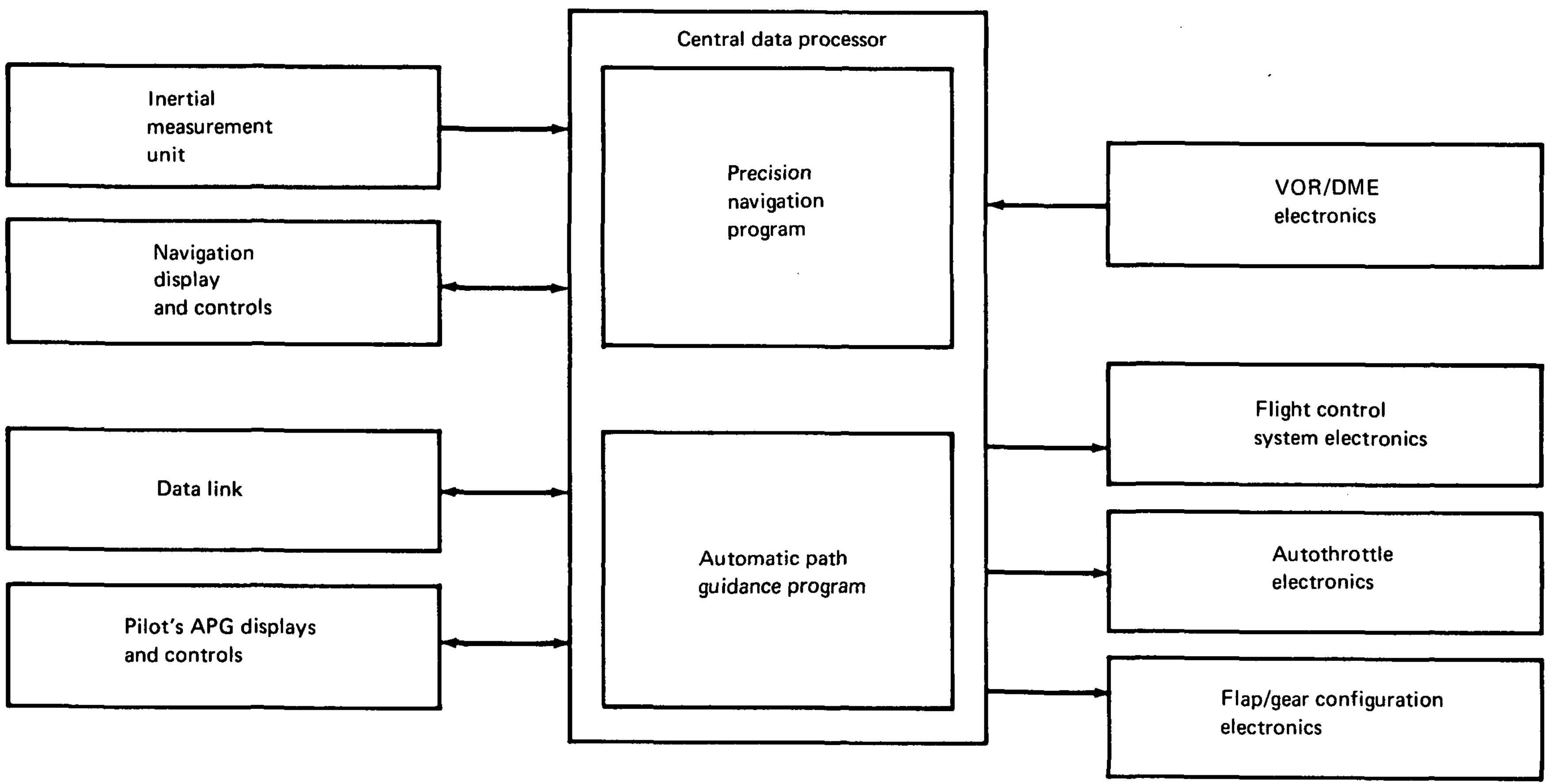


FIGURE 9-3.—AIRCRAFT SYSTEM

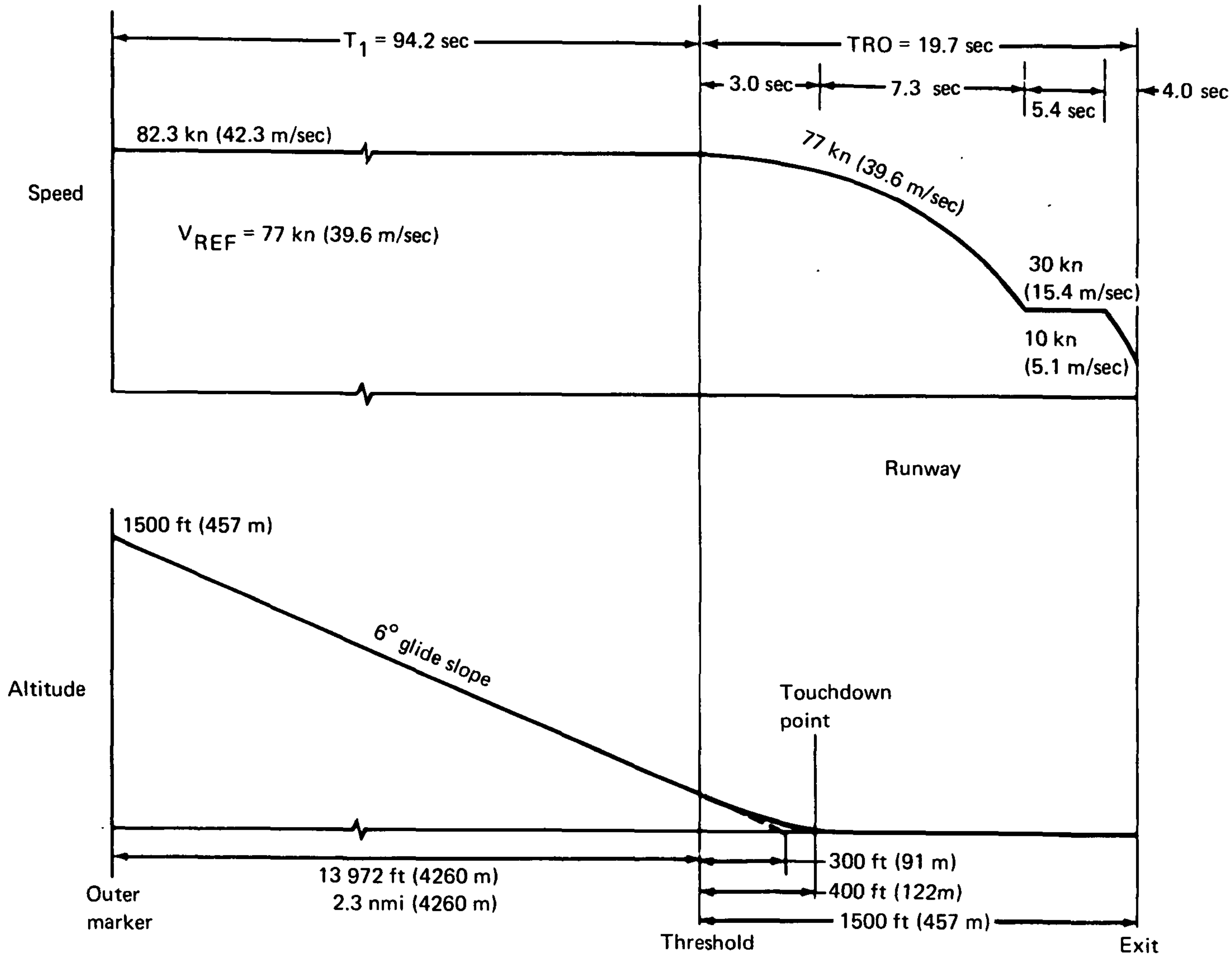
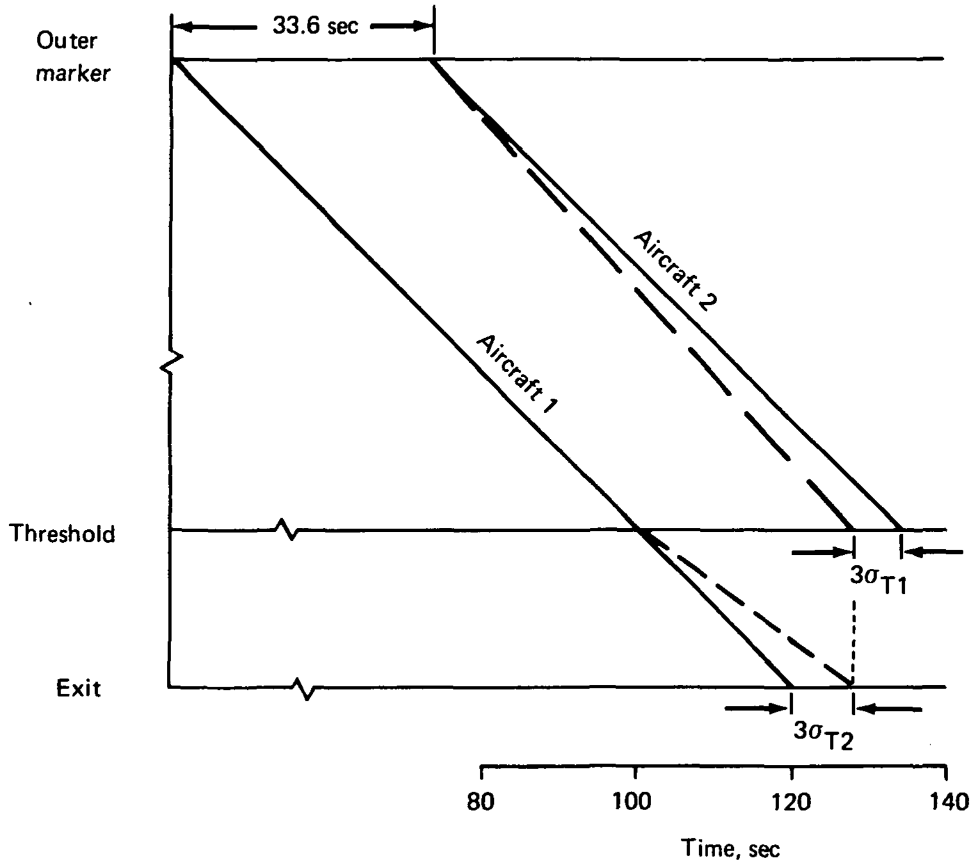


FIGURE 9-4.—APPROACH PROFILE



V_{REF} = 77 kn (39.6 m/sec)

$\sigma_{T2} = \sigma^2_{TRO} + \sigma^2_{T1}$

Expected value of runway acceptance rate = 107 aircraft/hour

Expected go-around rate $<$ 0.01% of runway acceptance rate

Longitudinal separation = 0.72 nmi (1330 m)

FIGURE 9-5.—REQUIRED ARRIVAL-ARRIVAL SEPARATION TIME

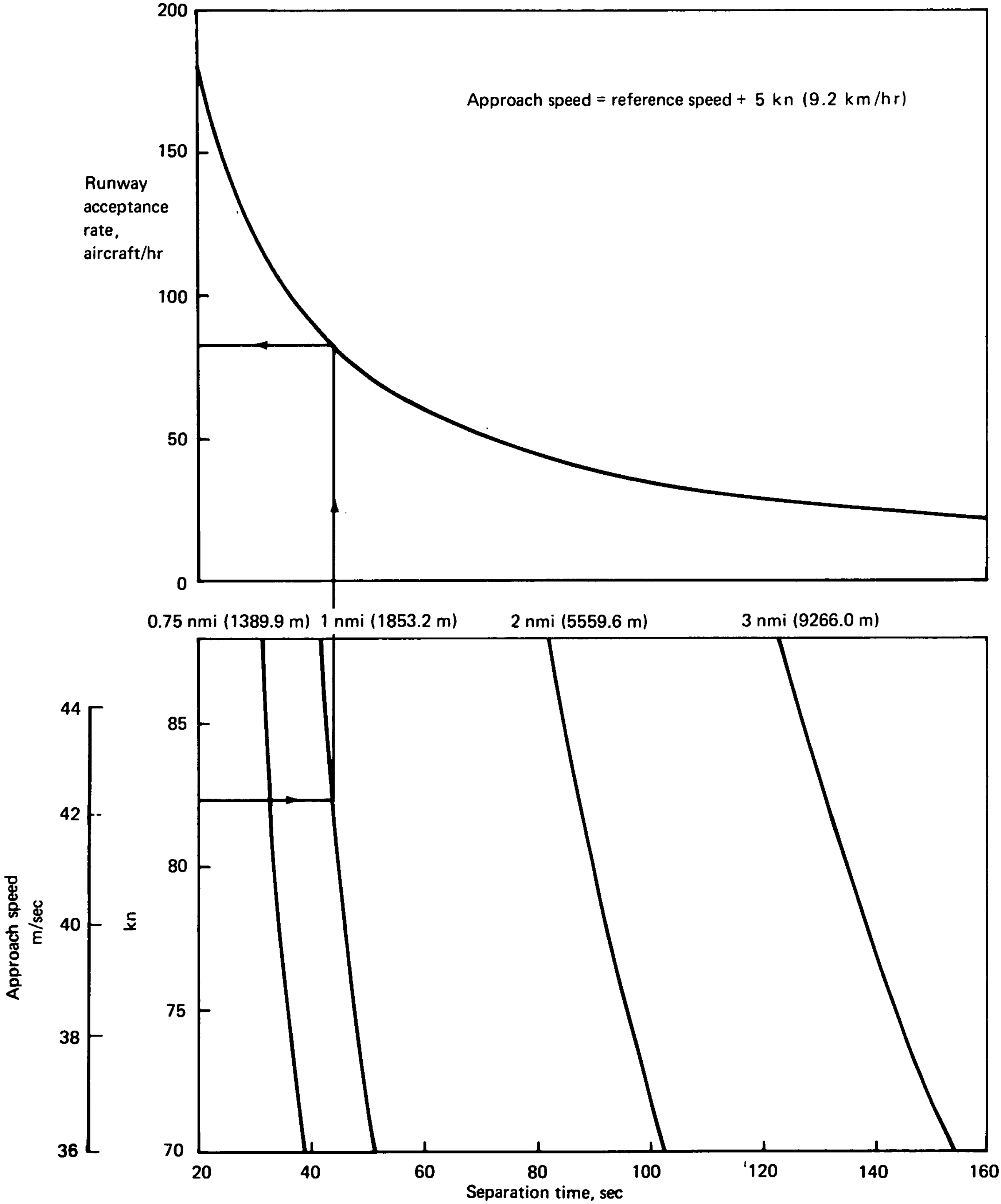


FIGURE 9-6.—RUNWAY ACCEPTANCE RATE VS REFERENCE SPEED

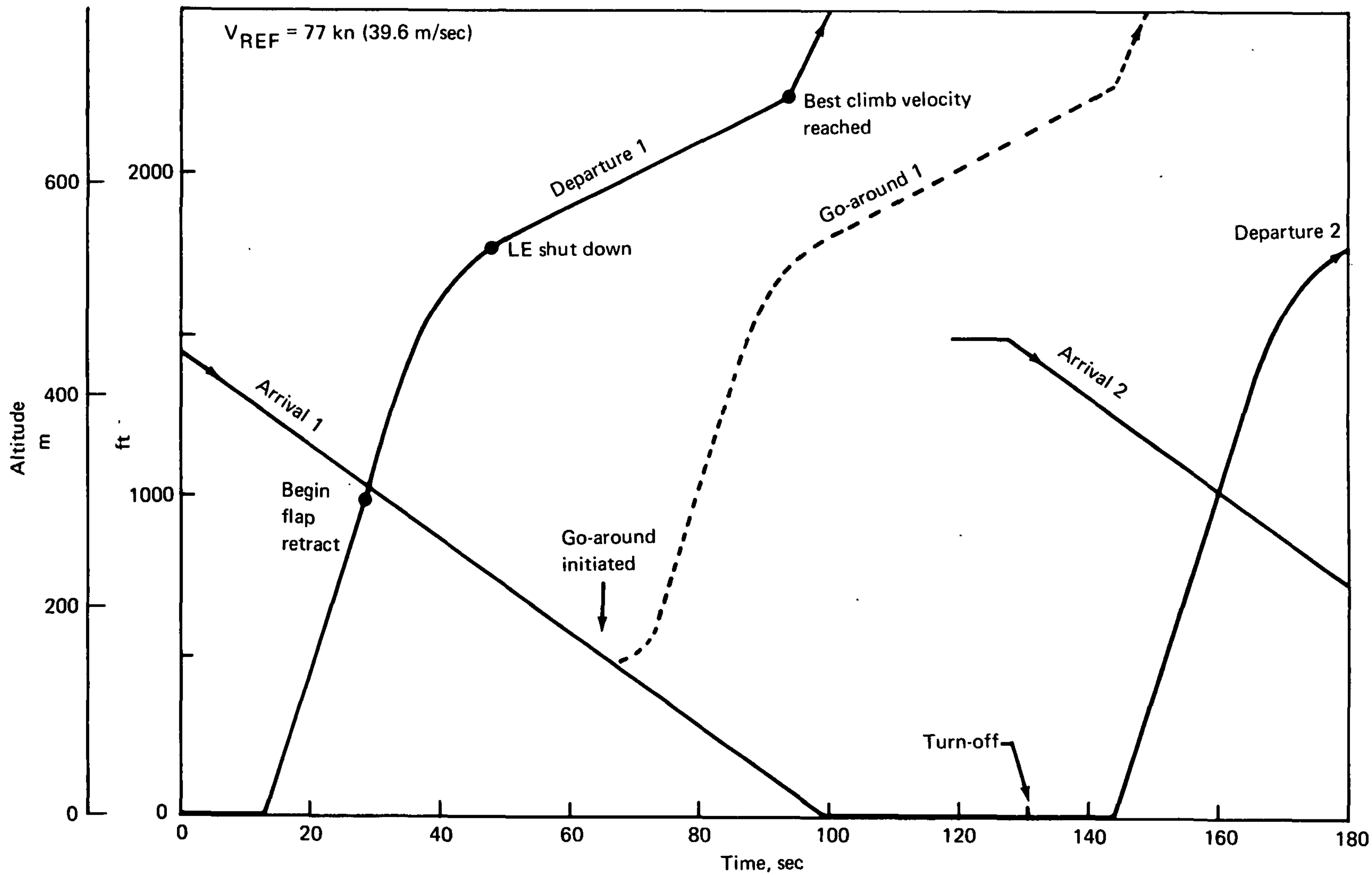


FIGURE 9-7.—3 NMI (5.55 KM) ARRIVAL-ARRIVAL SEPARATION ALTITUDE VS TIME

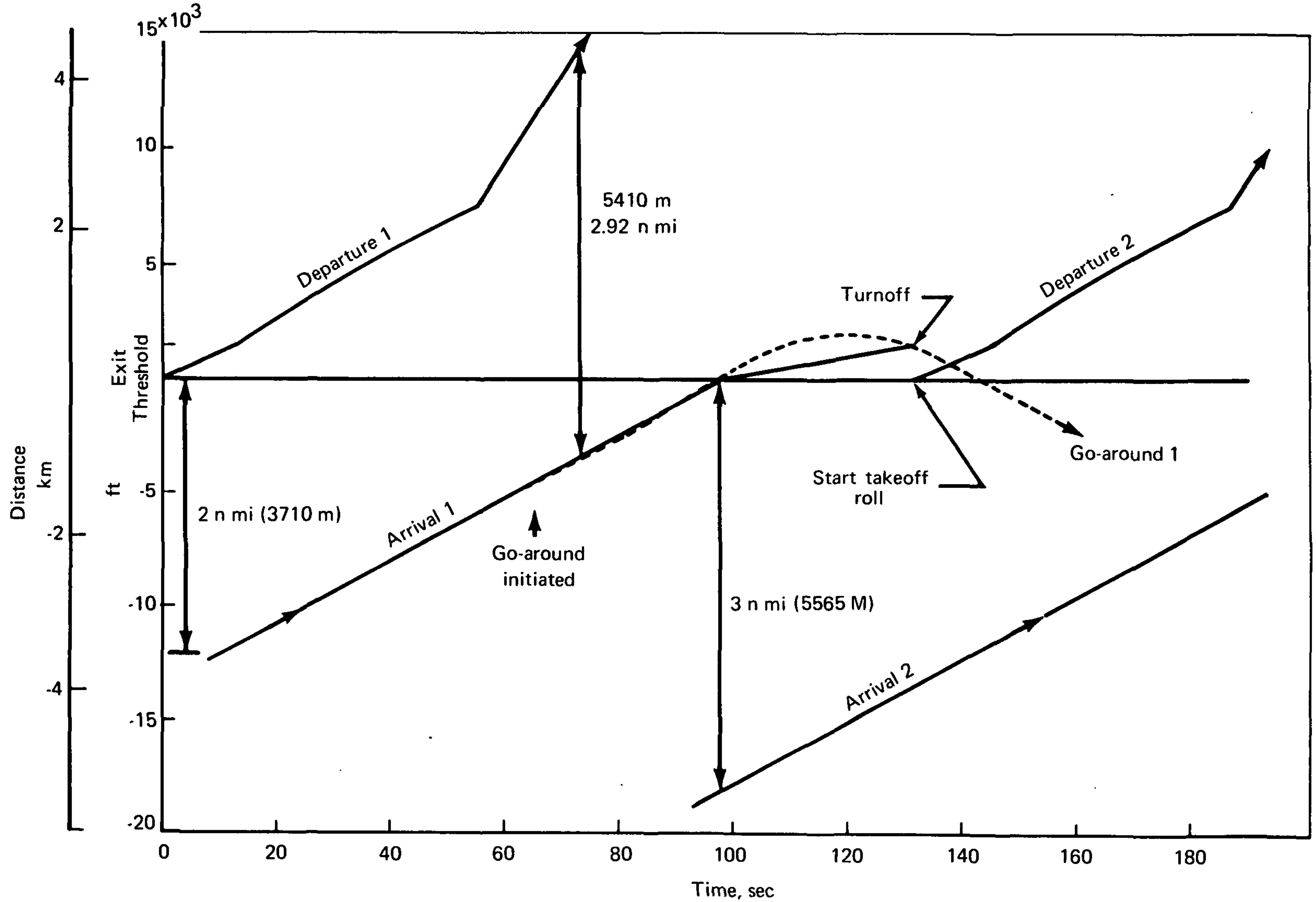


FIGURE 9-8.—3-NMI (5.55 KM) ARRIVAL -ARRIVAL SEPARATION DISTANCE VS TIME

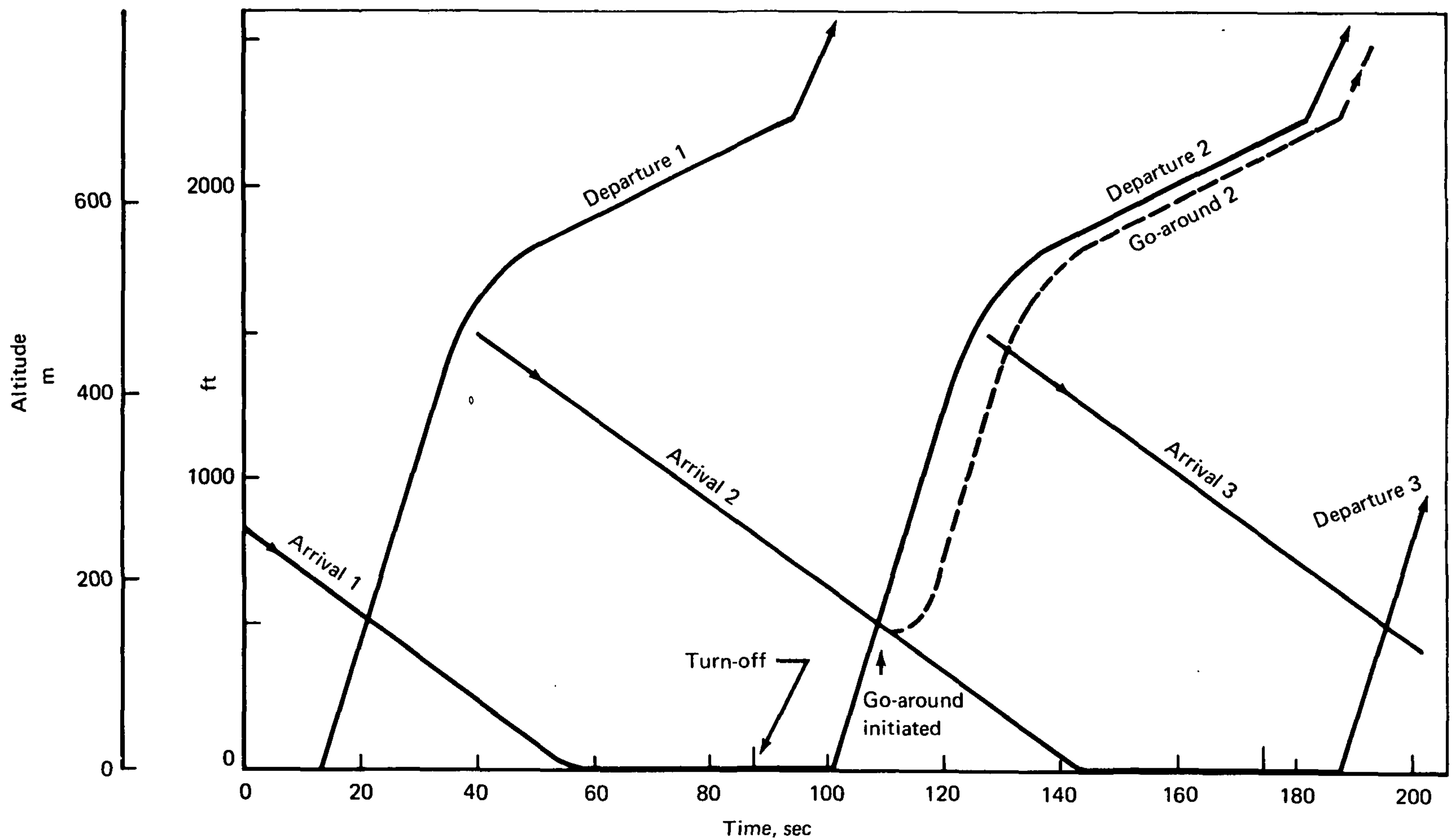


FIGURE 9-9.—2-NMI—(3.71 KM) ARRIVAL-ARRIVAL SEPARATION ALTITUDE VS TIME

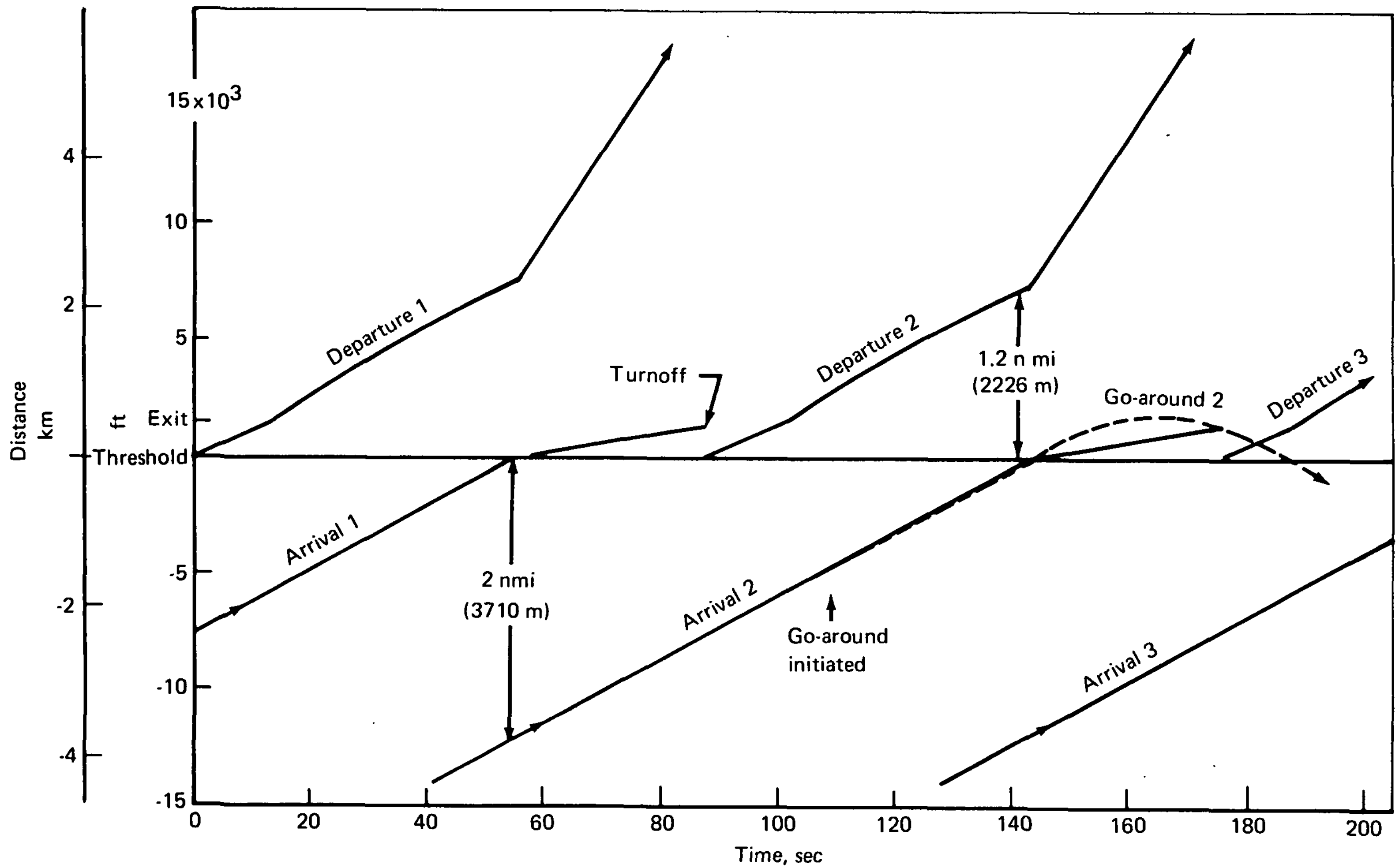


FIGURE 9-10.—2-NMI (3.71 KM) ARRIVAL-ARRIVAL SEPARATION DISTANCE VS TIME

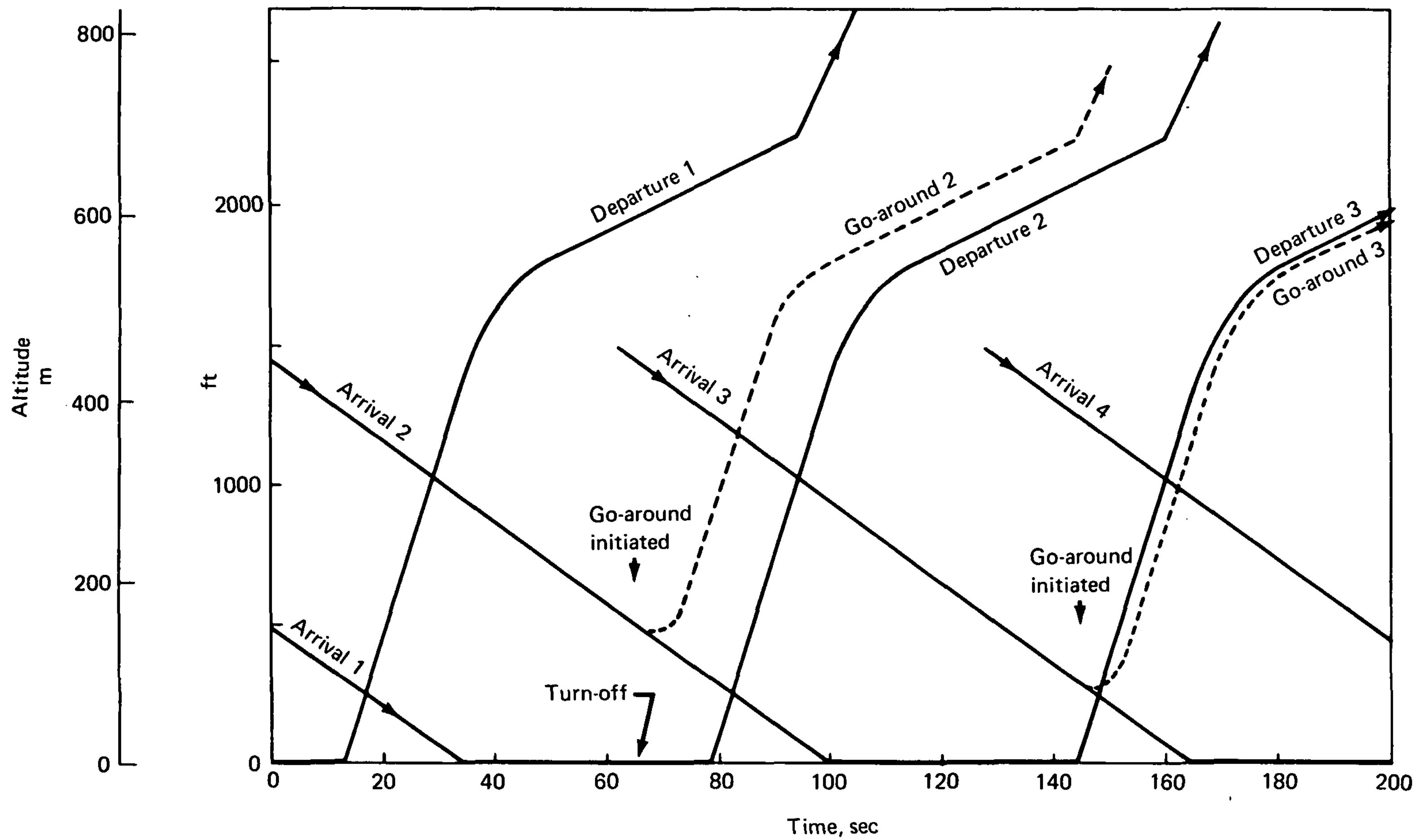


FIGURE 9-11.—1.5 NMI—(2.78 KM) ARRIVAL-ARRIVAL SEPARATION ALTITUDE VS TIME

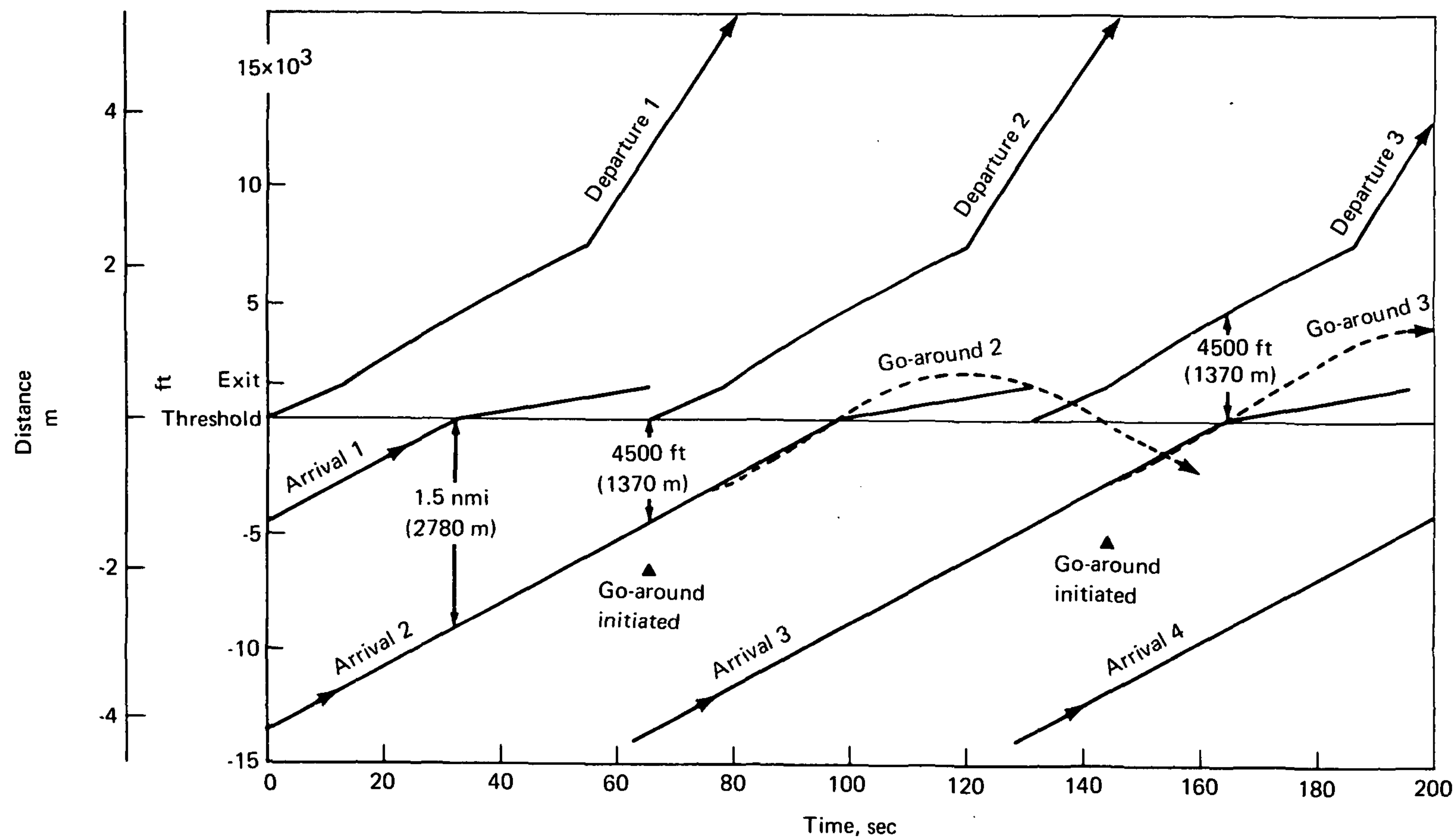


FIGURE 9-12.—1.5-NMI (2.78 KM) ARRIVAL-ARRIVAL SEPARATION DISTANCE VS TIME

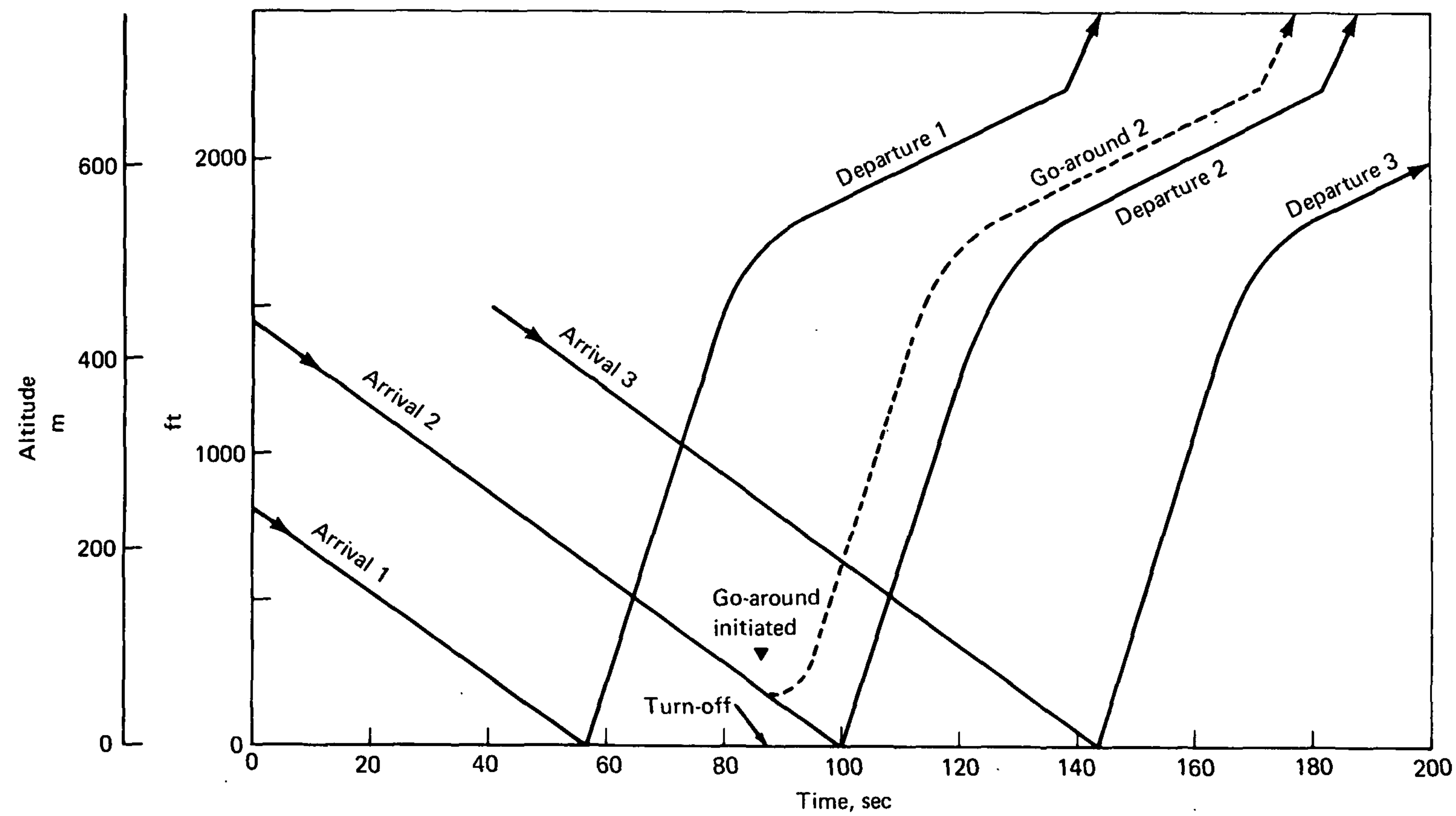


FIGURE 9-13.–1 NMI–(1.86 KM) ARRIVAL-ARRIVAL SEPARATION ALTITUDE VS TIME

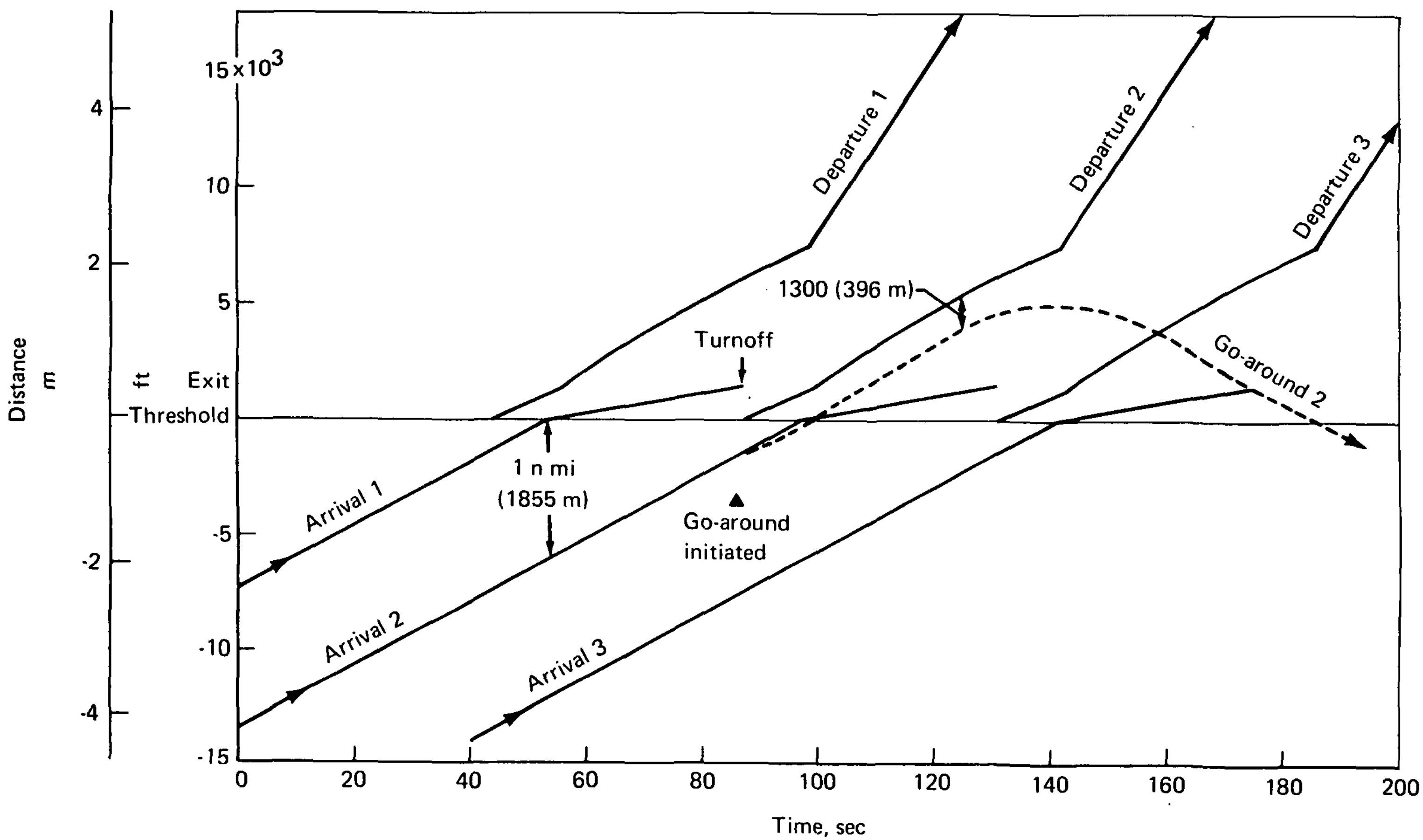


FIGURE 9-14.—1-NMI (1.86 KM) ARRIVAL-ARRIVAL SEPARATION DISTANCE VS TIME

10.0 OPERATING COST

There are three important considerations that must be investigated before embarking on a new system such as intraurban aircraft transportation: investment, public benefit, and operating profitability. Part of operating profitability is operating cost.

The intraurban transportation system is a unique concept, therefore, the methods developed to assess operating costs are also unique. The attributing factors—aircraft price, cash direct operating cost, cash indirect operating cost and allocated investment cost—have been separately analyzed to embody the intraurban system.

10.1 AIRCRAFT PRICE BUILDUP

The cost estimates for the intraurban configurations were developed through the use of a computerized cost model. This model provides the ability to display the cost of the fly-away aircraft systems by the following standardized classifications: wing, body, empennage, landing gear, nacelle, power pack, electrical, electronics, controls, hydraulics/pneumatics, air conditioning, and interiors.

Cost regression curves were developed for the above classifications based on both Boeing and industry data. The availability of this technique allows expedient evaluation for production quantities of any aircraft regardless of configuration. Each airplane configuration was then evaluated individually to establish the complexities of design, tooling, and manufacturing, relative to the basic regression cost curves developed, and adjusted by this evaluation to determine the relative magnitude of the tasks between the various designs.

The cost/price of the aircraft was based on a reasonable return on investment in a commercial environment. The total one-company market was assumed to be 1500 to 2000 aircraft at a peak rate of 30 per month.

If the cost/price of the aircraft were based on the same return on investment but a much smaller production quantity (300-400), the price would increase about 50%. For the 95-passenger augmentor wing STOL, the price would increase from \$1 968 000 to \$3 151 000. The effect of this on DOC is shown in section 10.2.6 and in the overall economic analysis in section 11.5.

Table 10-1 lists th cost/price for the three configurations at each of the passenger capacities for 1975 and 1985. The 1985 airframe cost is essentially the same as the 1975 airframe. This results in a slightly higher cost per pound for the 1985 technology composite construction. (See sec. 6.1.5.3 for costs of composite structure.)

10.2 CASH DIRECT OPERATING COST

Cash direct operating cost (DOC) includes crew pay, insurance, direct maintenance, direct maintenance burden, fuel, and oil. Depreciation is in allocated investment cost and, hence, not part of cash direct operating cost.

10.2.1 Crew Pay

Crew pay is based on a two-man crew—pilot and copilot. All regulations limiting the number of hours a crew may work per month, or annually, have been lifted. Crews will work regular shifts on a five-day week and will return home at the end of the shift.

The method used to derive a crew's yearly salary is based on an outline in a 1969 union/airline agreement. This includes a monthly base pay, hourly pay, mileage pay, gross weight pay, plus a 15% increase to cover welfare, payroll taxes, trainees, instructors, etc.

A variety of shifts was considered, as shown in figure 10-1. Although the yearly salary varies according to the length of the shift, the maximum change in dollars per block-hour from one shift to another is less than $5/hr. Since a variety of shifts may be employed, an average dollar per block-hour was used.

10.2.2 Insurance

Insurance included in direct operating cost covers the hull, public liability, and property damage. Passenger liability insurance is considered an indirect operating cost.

During the initial introduction of a new airplane type, the insurance is high, but, over the useful life of the airplane, it will average 2% per year when applied to the total initial airplane price.

10.2.3 Direct Maintenance

Direct maintenance expenses for the study were developed using two principal sources: from CAB Form 41 schedules for scheduled airlines and from airline sources where a more detailed breakdown exists. The following methodology discussion will show how the two sources are used to complement each other with the resulting maintenance estimates being more realistic.

Historical CAB Form 41 maintenance expenses were collected for a number of years to observe the relative contribution of airframe and engines on aircraft of significantly different design. Aircraft with differing design ranges, numbers of engines, and scheduled operating environments were compared. This allowed conclusions to be drawn on size, numbers of engines, and aircraft average trip length.

Four conventional aircraft averages were determined as representative of their types to be the basis of the subsequent estimations. Selected aircraft were:

- A large four-engine aircraft
- A medium three-engine aircraft
- Two smaller two-engine aircraft

The maintenance expenses of these four aircraft were separated into 13 major functional systems to provide the basis for estimating STOL maintenance expense levels. The 13 systems elected for estimating are combinations of the Air Transport Association (ATA) specification 100 breakdown for maintenance operations. The 13 systems are:

(1) Landing gear

(2) Body

(3) Wing

(4) Empennage

(5) Electronics and instruments

(6) Electrical

(7) Controls

(8) Nacelle

(9) Interiors

(10) Hydraulics and pneumatics

(11) Air conditioning

(12) Engines

(13) Power pack

Figures 10-2 through 10-5 present dollars per trip at the average flight time for the various systems. The extrapolations to the lower gross weights were the basis for the STOL estimates. These first-level estimates were then modified to account for major changes in design from conventional aircraft to the study aircraft. Examples of systems requiring judgmental modifiers are:

- Larger number of doors
- Low-speed takeoffs and landings that allow greater tire tread thickness
- Elimination of galleys, toilets, oxygen, and water/waste systems

Tables 10-2 and 10-3 list the 1975 and 1985 STOL estimates (based on conventional design) and modifying factors used in estimating maintenance costs for the study. By relating the modified estimates to the parameters of system weight and price, it was possible to estimate the effect of variations on the basic design.

All aircraft, except portions of the helicopter and tilt-rotor aircraft, were developed using the above basis. Vertol division provided the estimates of labor and materials for engines, power pack, rotor, drive, and control systems of the helicopter and tilt-rotor aircraft. The remaining systems were estimated in the above-described manner with helicopter reported costs being the base.

10.2.4 Direct Maintenance Burden

One and a half times the direct maintenance labor dollars has been used. CAB 1968 and 1969 statistics shows the average burden for small passenger aircraft is 150% of labor maintenance.

10.2.5 Fuel and Oil

Although domestic fuel prices have shown increases in the past year, the most commonly used fuel price of 10 cents per gallon ($26.40 per cu m) plus a 2% nonrevenue factor has been used in this study since a specific price forecast for the study area has not been made. Oil has no appreciable impact on direct operating cost and has, therefore, been excluded.

10.2.6 Analysis and Results

The purpose in analyzing the DOC is to aid in choosing a design to fulfill the intra-urban transportation system requirements. In this study, depreciation is an allocated investment cost and will not be included as a direct operating cost. Cash DOCs are used.

Three aircraft designs in two time periods have been analyzed. In a 1975 time period, the augmentor wing STOL design and a helicopter are compared. Each has three configurations. Figures 10-6 and 10-7 present the cash DOC comparison in dollars per trip versus range, and cents per seat-statute-mile versus range. In each configuration, the augmentor wing STOL has a lower cash DOC. This can be largely attributed to block time.

Figures 10-8 and 10-9 segregate the dollars per trip for the two aircraft into the cash DOC elements, adding depreciation for information only. Figure 10-10 gives the dollars-per-trip breakdown at 30 nmi (55.5 km) showing the cost due to fuel and hourly oriented costs above the line and those dependent on a yearly utilization below the line. Again, depreciation is shown for information only. For this section, an average utilization of 5 hr per day for 310 days per year (1550 hr per year) has been used.

The cost in cents per seat-statute-mile versus range for the three configurations and the cost in cents per seat-statute-mile versus number of passengers are shown in figures 10-11 and 10-12 for the two aircraft.

In the 1985 time period, an augmentor wing STOL aircraft, a helicopter, and a tilt-rotor VTOL aircraft are compared. In this time period, both the helicopter and the augmentor wing STOL are benefiting from improved technology and material expected to be available at this time. The tilt-rotor VTOL will not be available until this time period.

Figures 10-13 through 10-21 present the cash DOC for the 1985 aircraft in the same manner the previously discussed 1975 aircraft were shown. Figure 10-13 and 10-14 show that the tilt-rotor VTOL has slightly lower cash DOCs in all configurations than the augmentor wing STOL. The helicopter is higher at all ranges and configurations. Tilt-rotor VTOL flight time is only slightly higher than the augmentor wing STOL, but, as shown in figure 10-18, the tilt-rotor VTOL fuel consumed is lower.

Several sensitivity studies were run on the augmentor wing STOL for both the 1975 and 1985 time periods. They are: sensitivity on body configurations, takeoff field length, minimum-cost cruise speed, reduced production quantity, and a simplified engine that will reduce engine maintenance and price. In addition, a disc loading sensitivity study was run on the tilt-rotor VTOL.

The results of these sensitivity studies are presented in figures 10-22 through 10-28.

10.3. INDIRECT OPERATING COSTS

10.3.1 Introduction

The determination of indirect operating costs (IOC) for an airline system is, at best, highly subjective. IOC can be defined, generally, as all expenses incurred in airline activities not directly associated with the acquisition or operation of flight equipment. The rationale developed to quantify IOCs follows existing methods to some degree but modified, as required, by the uniqueness of the intraurban operations. The operating expense functions of the Civil Aeronautics Board's uniform system of accounts and reports are generally followed.

The quantification of IOC required analyzing the staff requirements, labor rates, and capital investments necessary to operate the system and to support the requirements of the basic system developed for the San Francisco Bay area.

The basic system that evolved is characterized by: short segments, high frequencies, single-class service, automatic ticketing and no reservations, minimum staffing, and an austere environment.

10.3.2 Description of Accounts

Each operating function in the IOC group was analyzed in detail and related to one or more pertinent operating statistical units of measure.

10.3.2.1 Passenger Service

Passenger service encompasses all activities related to passenger comfort, safety, and convenience. In this analysis, it is assumed that there will be no in-flight meals and, consequently, no need for cabin attendants.

There is one cost reported in this account that is relevant to the intraurban system—Passenger liability insurance. Historically, the cost of passenger liability insurance, as well as various unit costs for the domestic trunk airlines, have been as shown in table 10-4 (all figures are annual expense and are in constant 1968 dollars).

There does not appear to be any stability in the unit costs, although the trend is clearly toward lower unit costs. For the base system, the expected passenger liability expense would be $6.5 million, based on the 0.688 million departure rate. Again for the base system, the expected annual passenger liability expense would be $3.8 million, based on the 15.2 million passengers per year passenger rate. While it is realized that the intraurban system will require a large number of revenue departures, the anticipated aircraft control system will increase the safety of the system by about 50%. Therefore, the passenger liability expense per passenger trip will be set at 12.5 cents or 50% of the current rate. The total yearly passenger liability expense PLE is given by

$$PLE = 0.125\,(LF)(Seats)(Departures)$$

where:

$$\begin{aligned} LF &= \text{average load factor} \\ Seats &= \text{aircraft capacity per departure} \\ Departures &= \text{annual number of departures, millions} \end{aligned}$$

10.3.2.2 Aircraft Servicing

Aircraft servicing covers all expenses incurred on the ground incidental to the protection and control of the in-flight movement of aircraft—visual inspection, routine checking, servicing, and aircraft fueling—and other expenses incurred on the ground pertinent to readying for the arrival and departure of aircraft at terminal locations. In addition, landing fees are included in this account.

Aircraft servicing can be subdivided into the four general cost areas listed below. The average percent of the aircraft servicing account for domestic trunks is also listed.

Cost Area	Historical Average of Total, %
Aircraft control	14
Landing fees	19
Aircraft handling	38
Other expenses	29

Aircraft Control.—Aircraft control activity encompasses flight planning, meteorology, crew scheduling, and related work. It might be hypothesized that almost all of the aircraft

control function will be computerized and require a very minimal staff of people. It is assumed that three men per node (terminal) will be required or 24 man-hours per day. Thus,

$$\begin{aligned}\text{Annual aircraft control cost} &= (24\ \text{hr/day})(\text{rate/hour})(\text{days/year})(\text{nodes})\\ &= 24(\$5.00)(314\ \text{days})(\text{nodes})\\ &= \$37\,680(\text{nodes})\end{aligned}$$

where the \$5.00 per hour rate (\$10 000 annually) and the 314 days per year are assumed values for these parameters.

Landing fees.—Landing fees vary by airport location and are, in effect, a fee paid by the airline to the locale to use for construction and maintenance of terminal facilities. As such, landing fees are considered a part of the subsidy necessary to maintain the operation of the intraurban system and, therefore, will not be considered part of the IOC of the system. Terminal costs are discussed in section 8.0

Aircraft Handling.—Aircraft handling is related chiefly to the handling of airplanes at airport locations. It is assumed that four men are required for each gate at each airport location. Since demand, as expressed in departures, is not uniform over the entire day, it will be unnecessary to have all gates manned during the entire working day. To allow for peak demand, it is assumed that half of the gates at each location will be manned at all times (16 hr/day) and that the remaining gates will be manned for peak traffic (4 hr/day). Thus, at node i,

$$\text{Total man-hours per day} = \left[\left(\frac{N_i}{2}\right)(16)(4)\right] + \left[\left(\frac{N_i}{2}\right)(4)(4)\right]$$

$$= 40\ N_i$$

where N_i is the number of gates at node i. Therefore, for the system,

$$\text{Total man-hours} = \sum_i 40\ N_i = 40\ (\text{total gates in system})$$

$$\text{Total annual cost} = 40\ (\text{gates})(\text{rate/hour})(\text{days/year})$$

$$= 40\ (\$5.00)(314)(\text{gates})$$

$$= \$62\,800\ (\text{gates})$$

where the rate per hour is \$5.00 (\$10 000 annually) and a 314-day work year is assumed.

A second activity that falls in this cost category is the cleaning, refueling, and visual check of aircraft. It is assumed that this will be done during the evening at a remote site. Assuming two-man crews that are able to clean, refuel, and check the aircraft at the rate of two per hour, or one man-hour per aircraft, the number of man-hours per day for a given fleet size is:

$$\text{Man-hours} = 1.0(\text{fleet size})(\alpha)$$

where α is the proportion of the fleet serviced on a daily basis and has been set at 1.0. Then,

$$\begin{aligned}\text{Total annual cost} &= (\text{fleet size})(\text{rate/hr})(\text{days/year}) \\ &= (\text{fleet size})(\$5.00)(314) \\ &= (1570)(\text{fleet size})\end{aligned}$$

where the rate per hour is \$5.00 (\$10 000 annually) for a 314-day work year.

Other Aircraft Servicing Expenses.—This cost category includes employee costs, such as training and instruction, as well as the purchase of outside services and office equipment rentals. There is no totally acceptable method of identifying all costs associated with this cost category. Therefore, it will be assumed that this cost contributes 29% of the total aircraft servicing account cost or 35.8% of aircraft servicing costs, exclusive of landing fees. Therefore,

$$\begin{aligned}\text{Other} &= 0.358\ (\text{Acft servicing cost - landing fees}) \\ &= 0.358\ (\text{Acft control + acft handling + other}) \\ 0.642\ \text{other} &= 0.358\ (\text{Acft control + acft handling})\end{aligned}$$

$$\text{Other} = 0.558\ (\text{Acft control + acft handling})$$

Substituting the aircraft control and aircraft handling costs found in earlier sections yields

$$\begin{aligned}\text{Other} &= 0.558[37\ 680\ (\text{nodes}) + 62\ 800\ (\text{gates}) + 1570\ (\text{fleet size})] \\ &= 21\ 025(\text{nodes}) + 35\ 042(\text{gates}) + 876(\text{fleet size})\end{aligned}$$

The total estimated aircraft servicing cost (TASC) for the intraurban network is given by

$$\begin{aligned}\text{TASC} &= \text{Acft handling + acft control + other} \\ &= 58\ 705(\text{nodes}) + 97\ 842(\text{gates}) + 2446(\text{fleet size})\end{aligned}$$

10.3.2.3 Traffic Servicing

Traffic service encompasses the processing of revenue payloads at terminal locations. For this IOC study, the intraurban system will carry no cargo; thus, revenue payload consists of passengers and baggage. Included in this function are the charges generated by direct ticket sales.

Passenger handling expenses vary according to the size of the terminal as well as volume of traffic. To handle the anticipated volume of traffic, automatic ticketing is imperative. There is a system currently available that will satisfy the requirements of the intraurban transportation system. Recently PSA (Pacific Southwest Airlines) has installed self-service ticket dispensing machines at various airports. The device is an electromechanical unit in which the customer inserts any acceptable credit card, pushes destination and activator buttons, and receives a ticket in 4 sec. Cost of each machine, developed by Asteroid Corporation of San Diego, California is \$3000. Assuming that the cost and ticketing time of the unit is representative, the necessary number of ticketing units and the cost per gate can be determined.

The number of ticketing machines necessary for a gate is

$$m = \left[\frac{S}{t_B/t_P} + 1\right] = \left[\frac{St_P}{t_B} + 1\right]$$

$$= \mathrm{GILT}\left(\frac{St_P}{t_B} + 1\right)$$

where:

[ ] implies the greatest integer less than (GILT).

Assuming, for reliability purposes, that a 25% backup is required, the number of ticketing machines per gate is

$$1.25m = 1.25\ \mathrm{GILT}\left(\frac{St_P}{t_B} + 1\right)$$

Summing over all gates and nodes, the total number of ticketing machines M is given by

$$M = 1.25m(\text{gates})$$

$$= 1.25(\text{gates}) \left[\mathrm{GILT}\left(\frac{St_P}{t_B} + 1\right)\right]$$

Letting $t_P = 8$ sec and $t_B = 180$ sec,

$$M = 1.25\mathrm{GILT}(0.044S + 1)(\text{gates})$$

Letting S = 50, 100, and 150 yields,

$$\begin{aligned}\mathrm{GILT}(0.44S + 1) &= 3, \text{ if } S = 50\\ &= 5, \text{ if } S = 100\\ &= 7, \text{ if } S = 150\end{aligned}$$

or

$$\mathrm{GILT}(0.044S + 1) = 1 + 0.04S$$

The "chargeable" cost of the ticketing machines per year, assuming 10% depreciation, 10% principal, and 7% interest on investment is

$$\begin{aligned}0.27(\$3000/\text{machine})M &= 810[1 + 0.04(\text{seats})](\text{gates})(1.25)\\ &= 1012.5[1 + 0.04(\text{seats})](\text{gates})\end{aligned}$$

There is a flat monthly maintenance charge for the machines of \$100 per node. Thus, the yearly maintenance charge is \$1200(nodes)

Although the ticketing function is entirely self-service, there should be a ticket agent on site to handle problems with invalid credit cards, etc. The level of manpower required is 2.5 agents per node per day or 20 man-hours per node per day. Thus,

$$
\begin{aligned}
\text{Agent cost} &= 20(\text{rate/hour})(\text{days/year})(\text{nodes}) \\
&= 20(\$5.00)(314)(\text{nodes}) \\
&= \$31\,400\ (\text{nodes})
\end{aligned}
$$

where the rate per hour is \$5.00 \$10 000 annually) for a 314-day work year.

The nonlabor portion of this account, historically, has amounted to 30% of the labor cost. Thus the nonlabor contribution is 0.30(31 400)(nodes) or 9420(nodes). Summarizing the cost by component,

Ticketing units	= 1012.5[1 + 0.04 (seats)] (gates)
Maintenance	= 1200(nodes)
Agents	= 31 400(nodes)
Nonlabor	= 9420(nodes)
Total (TTSC)	= 42 020(nodes) + 1012.5(gates) + 40.5(seats)(gates)

10.3.2.4 Promotion and Sales

Promotion and sales includes all costs associated with the creation of public preference for the air carrier and stimulation of this mode of air travel, direct sales solicitation, confirmation of passenger space sold, development of tariffs and operating schedules, expense attributable to the operation of nondirect ticket offices, and agency commissions on ticket sales. It is anticipated that this expense can be eliminated entirely due to automatic ticketing and a no-reservation policy. Also, any advertising deemed necessary can be done through public service announcements. The monopoly position such a system enjoys will eliminate the necessity of advertising on a continual basis.

10.3.2.5 Servicing Administration

Servicing administration includes expenses of a general nature incurred in performing supervisory or administration activities for traffic servicing and aircraft servicing. Assuming one supervisory employee per 10 people and one administrative employee per three supervisory personnel, the following manpower is required:

$$
\begin{aligned}
\text{Total manpower per employee} &= \frac{1}{10} + \frac{1}{30} = \frac{4}{30} \\
\text{Total man-hours/day} &= 0.133(\text{traffic servicing labor hours} + \\
&\quad \text{aircraft servicing labor hours}) \\
&= 0.1333[40(\text{gates}) + 24(\text{nodes}) + \text{fleet size} + 20(\text{nodes})] \\
&= 0.1333[44(\text{nodes}) + 40(\text{gates}) + \text{fleet size}]
\end{aligned}
$$

Historically the nonlabor cost has been 33% of the labor cost or on a per-hour basis, it is equal to 0.0444[44(nodes) + 40(gates) + fleet size]

Therefore, the total annual servicing and administration cost (TSAC) is given by

$$\begin{aligned} \text{TSAC} &= (\text{rate/hour})(\text{days/year})(0.1778)[44(\text{nodes}) + 40(\text{gates}) + \text{fleet size}] \\ &= (7.50)(260)(0.1778)[44(\text{nodes}) + 40(\text{gates}) + \text{fleet size}] \\ &= 15\,225.2(\text{nodes}) + 13\,868.4(\text{gates}) + 346.71(\text{fleet size}) \end{aligned}$$

where the rate per hour is \$7.50 (\$15 000 annually) for a 260-day work year.

10.3.2.6 General and Administrative Costs

General and administrative expenses include all items of a corporate nature plus expenses incurred in performing activities that contribute to more than a single operating function such as general financial accounting activities, purchasing, legal, and general operational administration not directly applicable to a particular function.

Assuming three G&A personnel for every four servicing administation personnel, the equivalent man-hour ratio is:

$$\left(\frac{3}{4}\right)\left(\frac{4}{30}\right) = 0.10 \text{ man-hours attributable to aircraft and traffic servicing}$$

The total manhours for G&A is then

$$0.10[44(\text{nodes}) + 40(\text{gates}) + \text{fleet size}]$$

The nonlabor cost is assumed to be 67% of the labor cost. Thus, on a per-hour basis the nonlabor cost is

$$0.0667[44(\text{nodes}) + 40(\text{gates}) + \text{fleet size}]$$

The total G&A cost (TGAC) is

$$\begin{aligned} \text{TGAC} &= (\text{rate/hour})(\text{days/year})(0.1667)[44(\text{nodes}) + 40(\text{gates}) + \text{fleet size}] \\ &= (15.00)(260)(0.1667)[44(\text{nodes}) + 40(\text{gates}) + \text{fleet size}] \\ &= 28\,600(\text{nodes}) + 26\,000(\text{gates}) + 650(\text{fleet size}) \end{aligned}$$

where the rate per hour is \$15.00 (\$30 000 annually) for a 260-day work year.

10.3.2.7 Ground Facilities

This account is composed of the following costs:

(1) Depreciation–ground property and equipment–This function covers the depreciation of terminal, administrative, and maintenance facilities; construction costs; and expenses of general ground equipment. This cost is being included with the

other depreciation, and a discussion may be found in the sections on depreciation and on terminal construction and site purchase.

(2) Maintenance burden–ground equipment–The maintenance burden expense encompasses primarily a portion of the cost of administration of maintenance stocks and stores; keeping pertinent maintenance operation records; and scheduling, controlling, planning, and supervising maintenance operations.

(3) Direct maintenance–ground equipment–The direct maintenance account includes expenses related to repair and maintenance of ground property and equipment. Historically, it has contributed about 26% of the total ground facility expense.

The problem of identifying and defining all contributors to the above costs is difficult. However, it is a widely accepted fact that such expenses are highly correlated with their counterparts in direct operating costs. Currently, the ratios of IOC to DOC for accounts 5200 (item 3 above) and 5300 (item 2 above) for the domestic trunks are 0.10 and 0.12, respectively.

For the DOC, let

$$Y_{5200} = A_{5200} + B_{5200}(\text{distance})$$
$$Y_{5300} = A_{5300} + B_{5300}(\text{distance})$$

where Y_{5200} and Y_{5300} are measured in dollars per departure. Then, the corresponding equations for IOC are

$$Y'_{5200} = 0.10A_{5200} + 0.10B_{5200}(\text{distance})$$
$$Y'_{5300} = 0.12A_{5300} + 0.12B_{5300}(\text{distance})$$

where the units of Y'_{5200} and Y'_{5300} are in dollars per departure.

For a 95-seat airplane, the values of Y are shown in table 10-5 for two ranges. Using this information to solve for the values of A and B, gives

$$B_{5200} = \frac{27.36 - 23.29}{46 - 11.50} = \frac{4.07}{34.5} = 0.118$$
$$A_{5200} = Y_{5200} - B_{5200}(\text{distance})$$
$$= 23.29 - 0.118(11.5) = 21.92$$

Therefore,

$$Y_{5200} = 21.92 + 0.118(\text{distance})$$

For IOC, the cost per departure for 5200 is

$$Y'_{5200} = 2.192 + 0.0118(\text{distance}).$$

Repeating the process for 5300,

$$B_{5300} = \frac{18.58 - 15.47}{46 - 11.50} = \frac{3.11}{34.5} = 0.090$$

$$A_{5300} = Y_{5300} - 0.090(\text{distance})$$
$$= 15.47 - (0.090)(11.5) = 14.435$$

Therefore,

$$Y_{5300} = 14.435 + 0.090(\text{distance})$$

For the IOC, the cost per departure for 5300 is

$$Y_{5300} = 1.735 + 0.0108(\text{distance})$$

The total ground facility cost (TGFC) for a 95-seat airplane is given by

$$\text{TGFC} = \sum_{\text{dep}} (2.192 + 1.735) + (0.0118 + 0.0108)(\text{distance})$$
$$= 3.927(\text{departures}) + (0.0226)(\text{total miles flown})$$

If the above analysis is applied to DOC data for 49-seat and 150-seat airplanes, the values in table 10-5 are obtained. The slopes and intercepts are shown in table 10-6.

For the IOC, the cost per departure coefficients for each seating configuration are shown in table 10-7.

The coefficients, when plotted as a function of number of seats per aircraft in figure 10-29, are approximately linear. Therefore, $\Sigma A'$, $\Sigma B'$ can be expressed as linear functions of the number of seats per aircraft. Letting A' denote $\Sigma A'$ and B' denote $\Sigma B'$, we have

$$\text{Slope } A' = \frac{5.296 - 2.947}{101} = \frac{2.349}{101} = 0.0233$$
$$\text{Intercept} = 3.927 - (0.0233)(95) = 1.717$$
$$A' = 1.717 + (0.0233)(\text{seats})$$

$$\text{Slope } B' = \frac{0.0268 - 0.0188}{101} = \frac{0.0080}{101} = 0.0000792$$
$$\text{Intercept } B' = 0.0226 - (95)(0.0000792) = 0.0151$$
$$B' = 0.0151 + (0.0000792)(\text{seats})$$

The annual TGFC is given by

$$\text{TGFC} = \sum_{\text{DEP}} [A' + B'(\text{distance})]$$
$$= A'(\text{departures}) + B'(\text{total miles})$$
$$= [1.717 + (0.0233)(\text{seats})(\text{departures})$$
$$+ (0.0151 + (0.0000792)(\text{seats})](\text{miles flown})$$
$$= 1.717(\text{departures}) + 0.0233(\text{seats})(\text{departures})$$
$$+ 0.0151(\text{miles flown}) + 0.0000792(\text{seats})(\text{miles flown})$$

Summarizing the STOL IOC by cost component yields table 10-8.

The annual IOC is given by the following formula, using the totals from table 10-9.

$$\begin{aligned}\text{IOC} = {} & 0.14458(\text{nodes}) + 1.717(\text{departures}) + 0.0151(\text{miles flown}) \\ & + 0.138723(\text{gates}) + 0.000040 52(\text{gates})(\text{seats}) + 0.003443(\text{fleet}) \\ & + 0.0233(\text{departures})(\text{seats}) + 0.125(\text{departures})(\text{seats})(\text{load factor}) \\ & + 0.0000792(\text{seats})(\text{miles flown})\end{aligned}$$

This equation has been inserted directly into the transportation network model (sec. 11.0) so that the IOCs for each vehicle in each system studied are consistent. The network model supplies the number of departures, miles flown, etc.

10.3.3 Calculation of IOC for the Base Case

The operating values for the base case are:

Nodes–26

Gates–48

Fleet–73

Passengers–15.245 million annually

Departures–0.68766 million annually

Miles flown–17.297 million annually

Load factor–0.447

Seats per aircraft–49

Departures per gate–14 326 per year

Miles per departure–25.15

Departures per aircraft–9420 per year

The IOC for the base case is broken out by component using the values of table 10-9.

Component	Cost	Percent
Aircraft servicing	6.402	42.8
Traffic servicing	1.236	8.3
Servicing administration	1.087	7.3
General and administrative	2.039	13.6
General facilities	2.294	15.4
Passenger liability expense	1.883	12.6
Totals	14.941	100.0

IOC per passenger departure = $0.9705

Figures 10-30, 10-31, and 10-32 graphically depict IOC as a function of the volume of passengers for various aircraft capacities. Note that the passenger liability expense and the expense related to the number of nodes have been identified. Also identified is the IOC for a constant number of departures (687 660 from the base case). It is interesting to note, as table 10-9 reveals, that a large number of additional passengers can be handled at a small incremental addition to the IOC. The dollar per passenger figures above assume that the parametric relationships indicated in figures 10-30, 10-31, and 10-32 are maintained. Since these parameters are not independent, it is probable that, as traffic increases, the number of nodes, gates, fleet size, etc., would vary, resulting in less-favorable ratios. These figures have been included primarily to illustrate the variability of the IOCs and should not be used alone to determine any sensitivities, unless a network model run is available showing the relationship between the parameters.

A number of interesting relationships can be seen in table 10-10, which compares the base intraurban system with the average of the domestic trunks, local service airlines, and helicopter airlines. The dollars per passenger carried for the intraurban system is less than one-twentieth of the trunks and less than one-tenth of the local service, but the dollars per revenue passenger mile turn out to be of a similar magnitude.

One last comment should be made concerning the IOC of the intraurban system. The assumptions made herein have purposely forced IOC to very low levels. It is felt that only at these levels does the system have any possibility of being economically feasible. The IOC cost calculated here should be viewed not only as an estimate of what IOC levels the intraurban system will incur for various aircraft types but also as an indication of manpower and staffing ratios necessary to attain these cost levels. It should be evident that austerity will not only be necessary but mandatory.

TABLE 10-1.—AIRCRAFT ACQUISITION COSTS

Aircraft type	Passenger capacity	1975 technology, 1970 dollars in millions			1985 technology, 1970 dollars in millions		
		Airframe[a]	Engines	Total	Airframe[a]	Engines	Total
Augmentor wing STOL	49	1.121	0.438	1.559	1.140	0.430	1.570
	95	1.423	0.545	1.968	1.432	0.531	1.963
	153	1.787	0.685	2.472	1.783	0.663	2.446
Helicopter VTOL	50	1.449	0.228	1.677	1.449	0.211	1.660
	98	1.992	0.355	2.347	1.992	0.331	2.323
	150	2.440	0.452	2.892	2.440	0.441	2.881
Tilt rotor VTOL	50			–	1.323	0.239	2.481
	100			–	1.946	0.377	2.323
	150			–	2.481	0.488	2.969

[a] Includes $305 000 for electronics in all cases

TABLE 10-2.—DIRECT MAINTENANCE COST—1975
($/Trip at Average Flight Time)

Airplane components	Curve value conventional aircraft at 60 400 lb gross weight	% change	Analysis	STOL augmentor wing value
Wing	0.65			0.65
Body	2.08		Extra doors may bring maintenance up, but because of slower speed window maintenance should go down.	2.08
Empennage	0.28			0.28
Landing gear	5.33	-35	Nonretractable gear, slower landing speed, and thicker tires improve number of takeoffs/set of tires.	3.47
Nacelle	0.21			0.21
Electrical	1.20	-35	Less complex system—no individual lights, galley, toilet lights, etc.	0.77
Electronics and instruments	1.63		This is a highly complex system, but because of airplane use the electronic system can be left on during shift, eliminating high cycle cost.	1.63
Controls	0.60			0.60
Hydraulics and pneumatics	1.07			1.07
Air conditioning	0.84	-50	No pressurization.	0.42
Interiors	3.76	-40	Galleys, toilets, oxygen, and water/ waste eliminated.	2.23
Power pack	3.20	-30	Augmentor wing power pack is smaller than that of conventional airplanes. Monitoring is installed and on-condition maintenance provided.	2.17
Engines	14.40	-30	Engines are overdesigned to improve cycle cost, although engines are still smaller than those of conventional airplanes because of augmentor wing. Monitoring is installed and on-condition maintenance provided.	9.80
Total	35.25			25.38

TABLE 10-3.–DIRECT MAINTENANCE COST–1985
($/Trip at Average Flight Time)

Airplane components	Curve value conventional aircraft at 48 500 lb gross weight	% change	Analysis	STOL augmentor wing value
Wing	0.52	+20	Ducting is more complex than in 1975 airplanes.	0.62
Body	1.72		Extra doors may bring maintenance up, but because of slower speed window maintenance should go down.	1.72
Empennage	0.20			0.20
Landing gear	4.30	-35	Nonretractable gear, slower landing speed, and thicker tires improve number of takeoffs/set of tires.	2.80
Nacelle	0.18			0.18
Electrical	0.94	-35	Less complex sytem–no individual lights, galley, toilet lights, etc.	0.60
Electronics and instruments	1.25		This is a highly complex system, but because of airplane use the electronic system can be left on during shift, eliminating high cycle cost.	1.25
Controls	0.45			0.45
Hydraulics and pneumatics	0.87			0.87
Air conditioning	0.62	-50	No pressurization.	0.31
Interiors	3.00	-40	Galleys, toilets, oxygen, and water/ waste elininated.	1.80
Power pack	2.80	-30	Augmentor wing power pack is smaller than that of conventional airplanes. Monitoring is installed and on-condition maintenance provided.	1.90
Engines	12.56	-30	Engines are overdesigned to improve cycle cost, although engines are still smaller than those of conventional airplanes because of augmentor wing. Monitoring is installed and on-condition maintenance provided.	8.54
Total	29.41			21.24

TABLE 10-4.—PASSENGER LIABILITY INSURANCE HISTORY—DOMESTIC TRUNK AIRLINES

Year	1969	1968	1967	1966	1965
Total liability cost (millions)	$29.6	$32.6	$30.9	$28.1	$27.1
Cost/departure	9.42	10.85	11.23	12.29	12.03
Cost/rpm	0.00032	0.00038	0.00041	0.00047	0.00053
Cost/passenger	0.252	0.299	0.318	0.355	0.387

TABLE 10-5.—MAINTENANCE DOC—AUGMENTOR WING STOL

	49 passenger		95 passenger		150 passenger	
Range	Y_{5200} [a]	Y_{5300} [b]	Y_{5200}	Y_{5300}	Y_{5200}	Y_{5300}
10 nmi	17.81	11.52	23.29	15.47	30.88	20.97
40 nmi	21.25	14.19	27.36	18.58	35.73	24.63

[a] Y_{5200} = Direct maintenance—dollars per departure

[b] Y_{5300} = Maintenance burden—dollars per departure

TABLE 10-6.—MAINTENANCE DOC—SLOPES AND INTERCEPTS

Seats	A_{5200}[a]	B_{5200}[b]	A_{5300}	B_{5300}
49	16.72	0.095	10.63	0.0775
95	21.92	0.118	14.44	0.090
150	29.26	0.141	19.75	0.106

[a] A = dollars/departure at zero range (intercept)

[b] B = dollars/mile (slope)

TABLE 10-7.—IOC COEFFICIENTS—GROUND FACILITY COSTS

Seats	A'_{5200}	B'_{5200}	A'_{5300}	B'_{5300}	$\Sigma A'$	$\Sigma B'$
49	1.672	0.0095	1.275	0.0093	2.947	0.0188
95	2.192	0.0118	1.735	0.0108	3.927	0.0226
150	2.926	0.0141	2.370	0.0127	5.296	0.0268

TABLE 10-8.—IOC COEFFICIENT SUMMARY

Cost category	Parameter						
	Nodes	Departures, millions	Gates	Miles, millions	Fleet size	(Seats) (dep), millions	Seat miles, millions
Total aircraft servicing cost (TASC)	0.058705		0.097842		0.002446		
Traffic servicing cost (TTSC)	0.042020		0.001013 + (0.00004052) (seats)				
Servicing and administration cost (TSAC)	0.015255		0.013868		0.000347		
General and administration cost (TGAC)	0.0286		0.026		0.00065		
Ground facility cost (TGFC)		1.717		0.0151		0.0233	0.0000792
Passinger liability expense (PLE)						(0.125)LF	
Totals	0.144580	1.717	0.138723 + (0.00004052) (seats)	0.0151	0.003443	0.0233 + (0.125)LF	0.0000792

TABLE 10-9.–IOC LOAD FACTOR–CAPACITY SENSITIVITY

Load factor	Capacity, seats		
	49	95	150
0.31	\$1.367/passenger	\$0.805/passenger	\$0.585/passenger
0.447	\$0.986/passenger	\$0.596/passenger	\$0.444/passenger
0.58	\$0.788/passenger	\$0.488/passenger	\$0.371/passenger

TABLE 10-10.–SUMMARY OF COMPARATIVE OPERATING STATISTICS FOR VARIOUS CLASSES OF SERVICE

Class of service[a]	Passengers, millions	Departures, millions	RPM, billions	IOC, millions	IOC unit costs		
					\$/pax	\$/dep	\$/RPM
Domestic	116.671	3.142	90.393	2417.535	20.72	769.0	0.0267
Local	23.388	1.594	6.473	266.835	11.41	167.0	0.0412
Helicopter	0.418	0.064	0.011	4.4	10.52	69.0	0.4000
Intraurban	15.245	0.688	0.356	14.941	0.95	21.0	0.0420

[a]Data for the STOL network is from the base case. Data for domestic, local, and helicopter service is from 1969 CAB handbook.

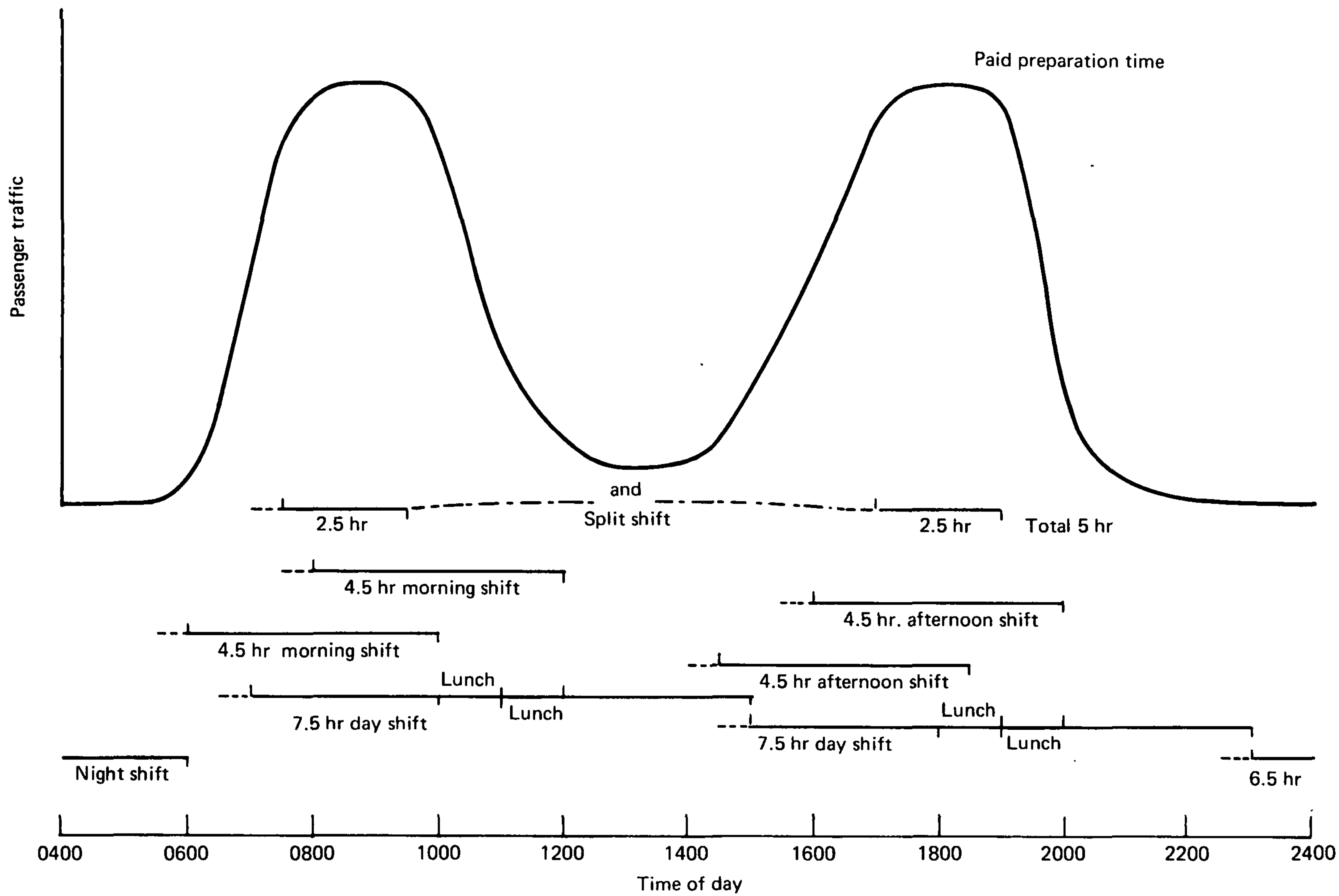


FIGURE 10-1.—FLIGHT CREW WORK SHIFTS—PASSENGER TRAFFIC VS TIME OF DAY

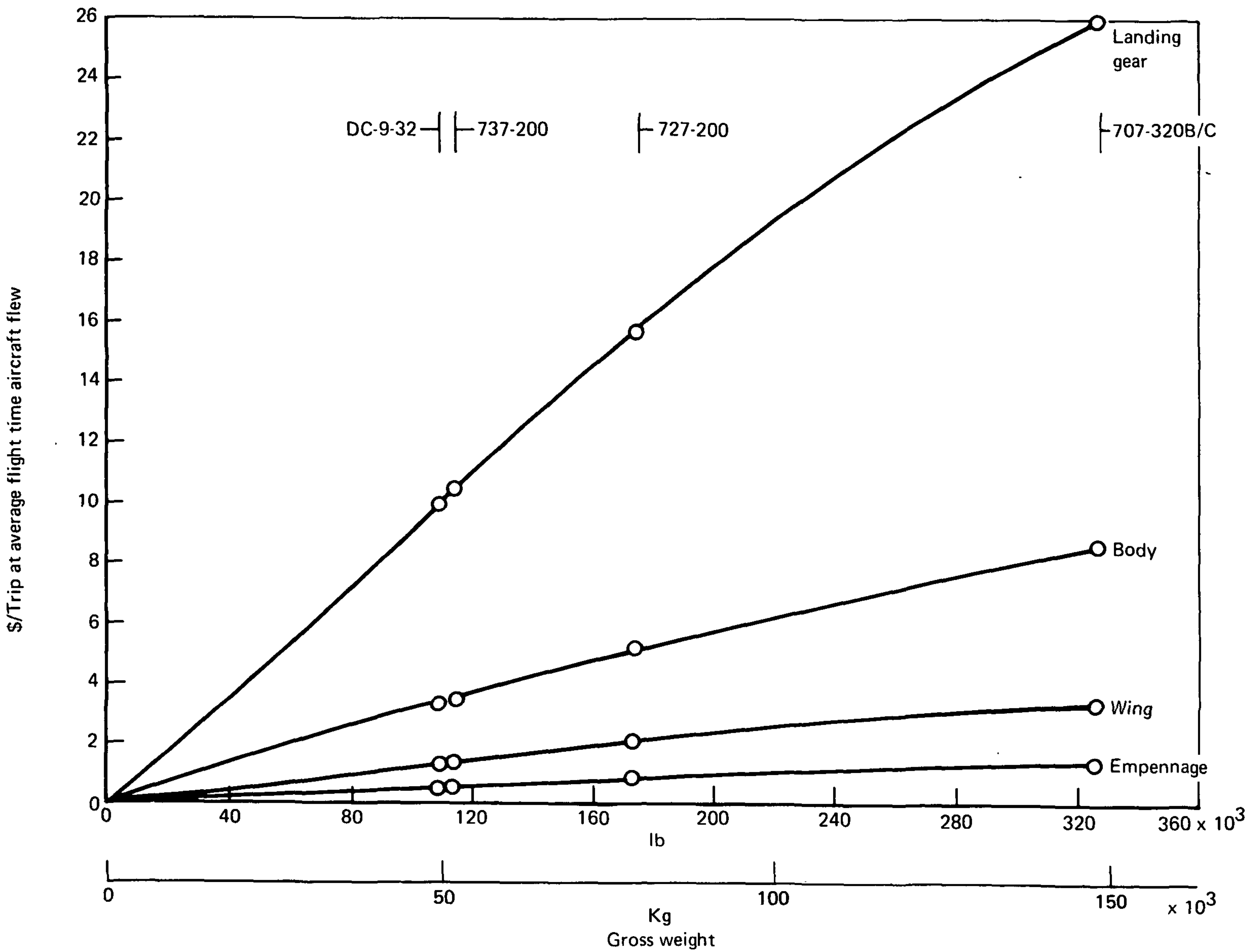


FIGURE 10-2.–DIRECT MAINTENANCE–DOLLARS/TRIP VS GROSS WEIGHT

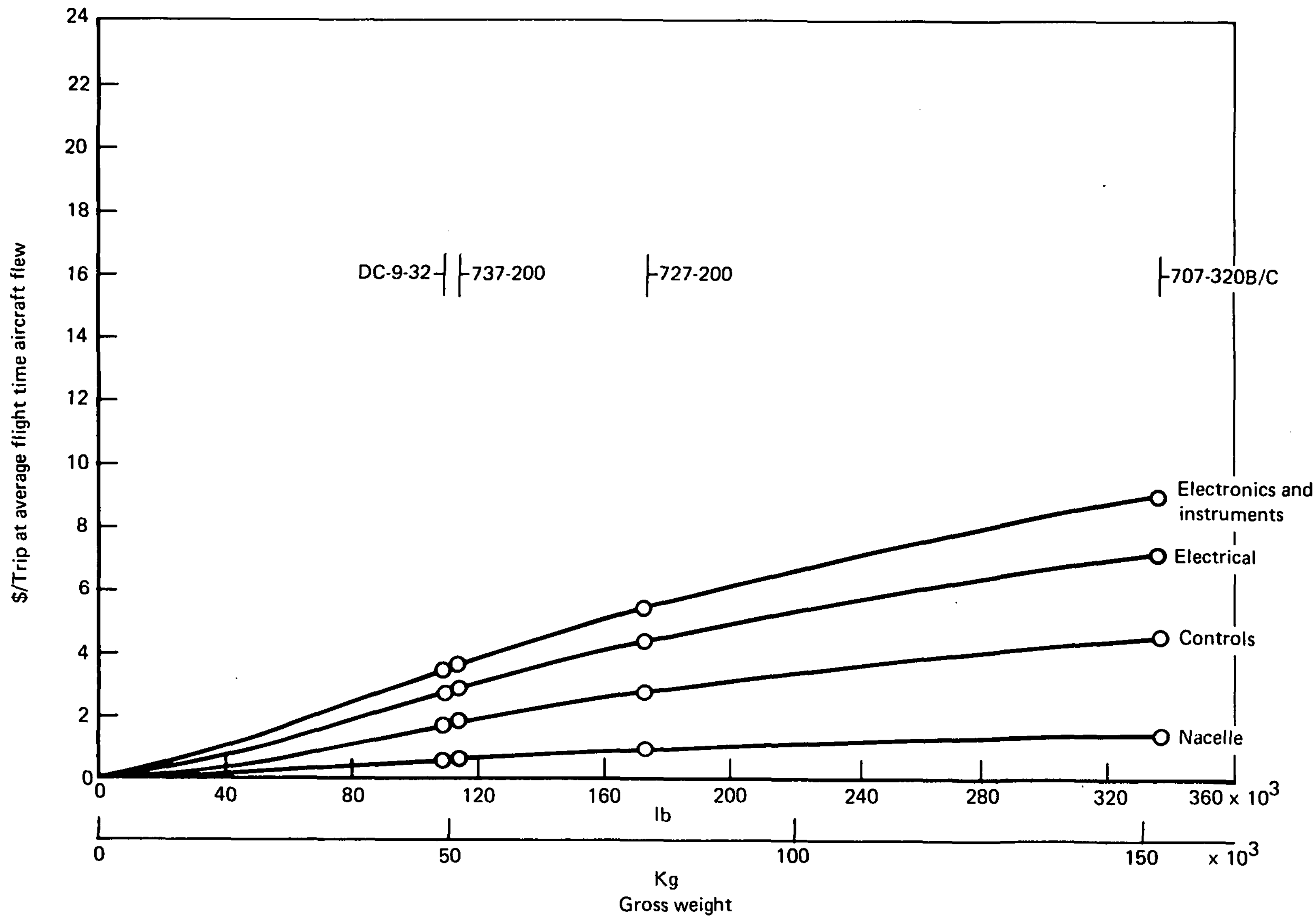


FIGURE 10-3.—DIRECT MAINTENANCE—DOLLARS/TRIP VS GROSS WEIGHT

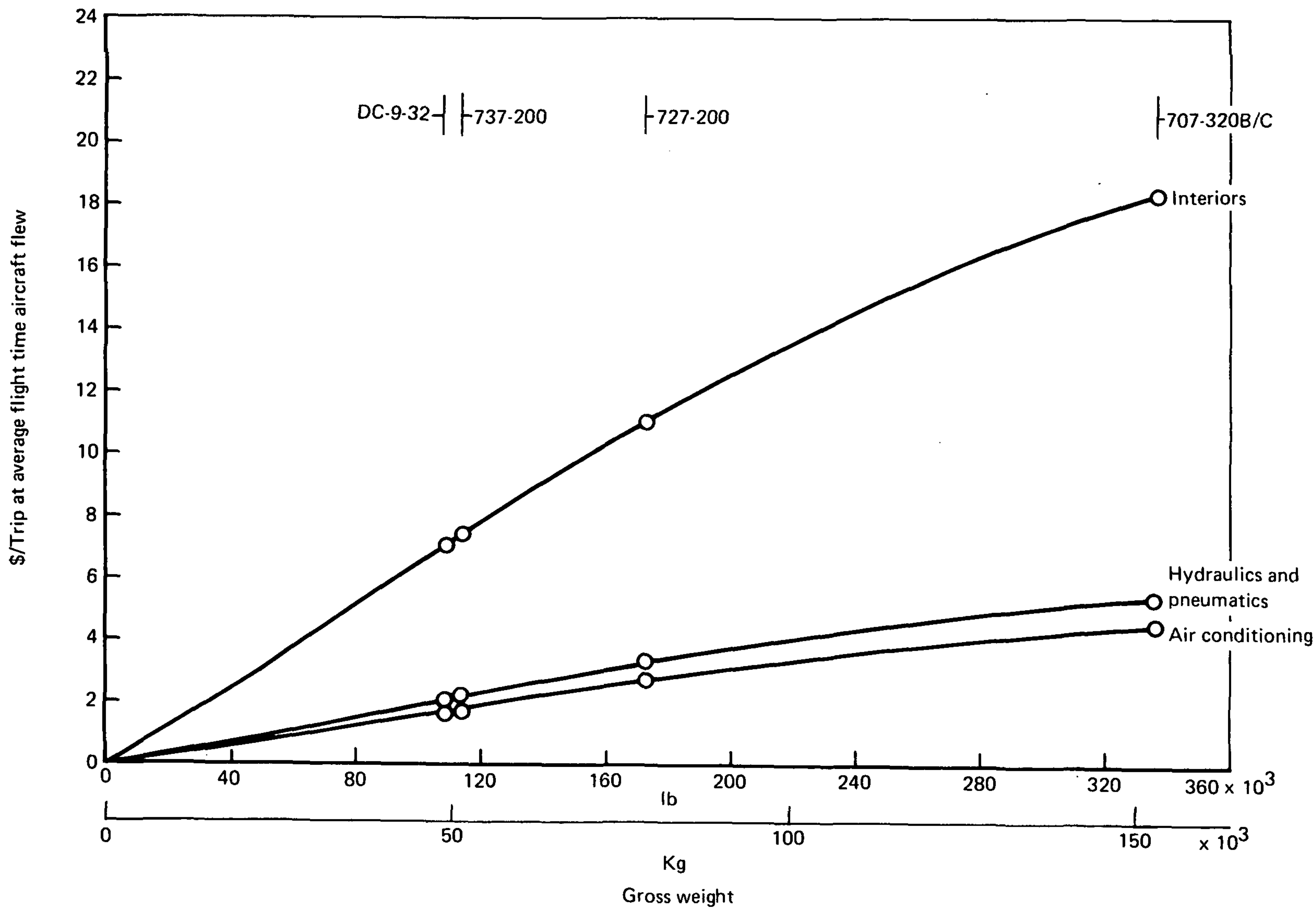


FIGURE 10-4.—DIRECT MAINTENANCE—DOLLARS/TRIP VS GROSS WEIGHT

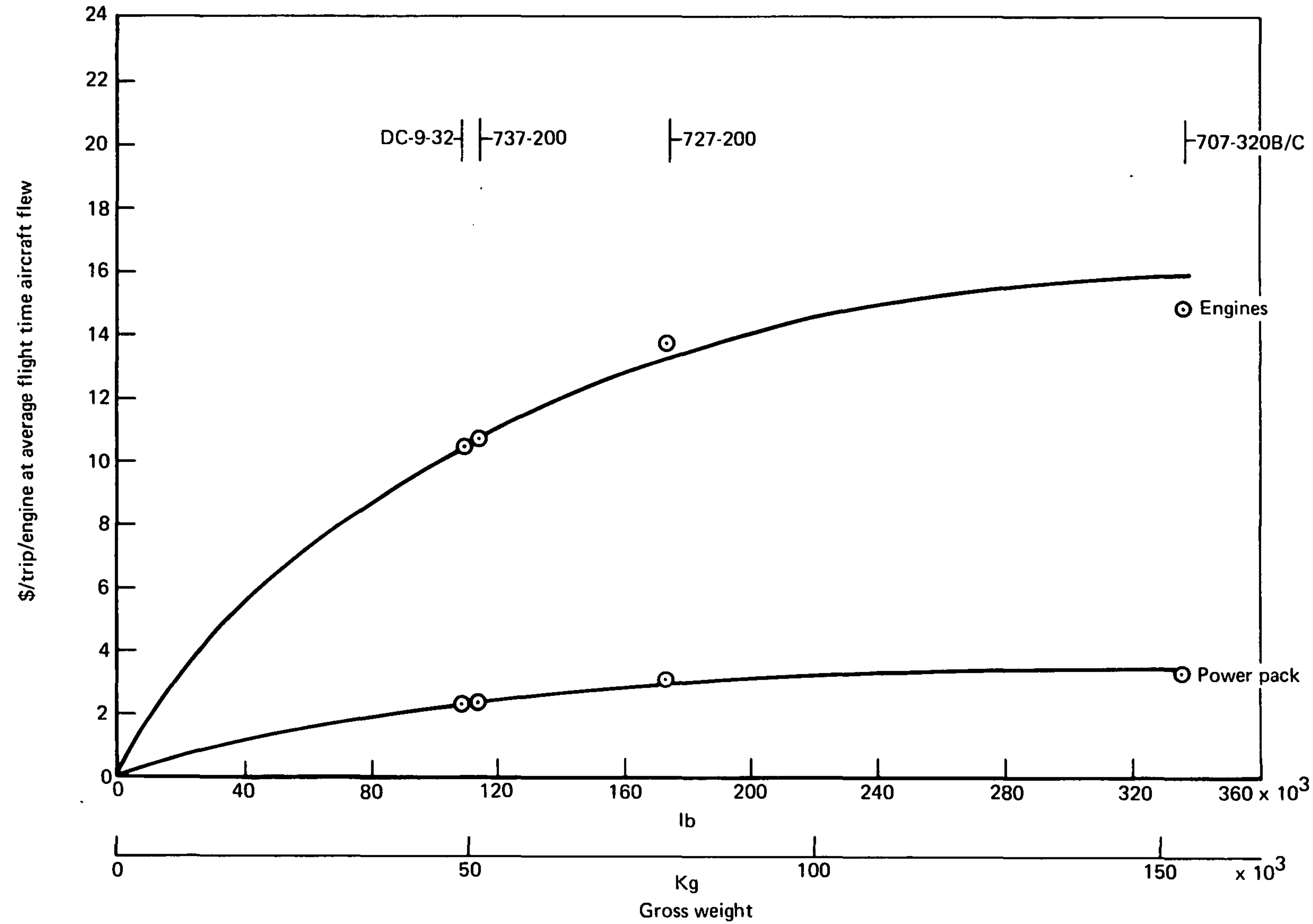


FIGURE 10-5.–DIRECT MAINTENANCE–DOLLARS/TRIP/ENGINE VS GROSS WEIGHT

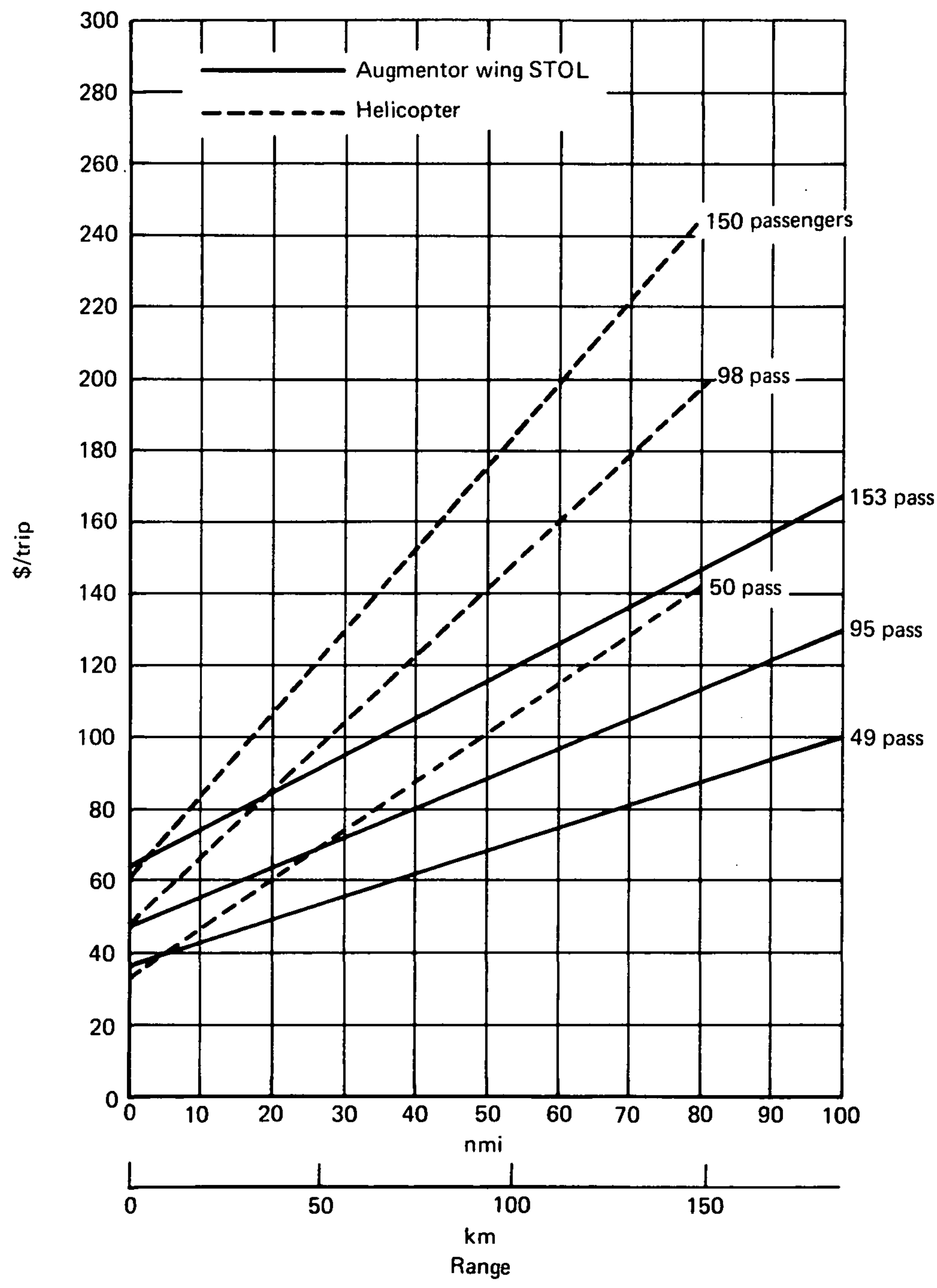


FIGURE 10-6.—CASH DIRECT OPERATING COST MINUS DEPRECIATION (1975)—$/TRIP

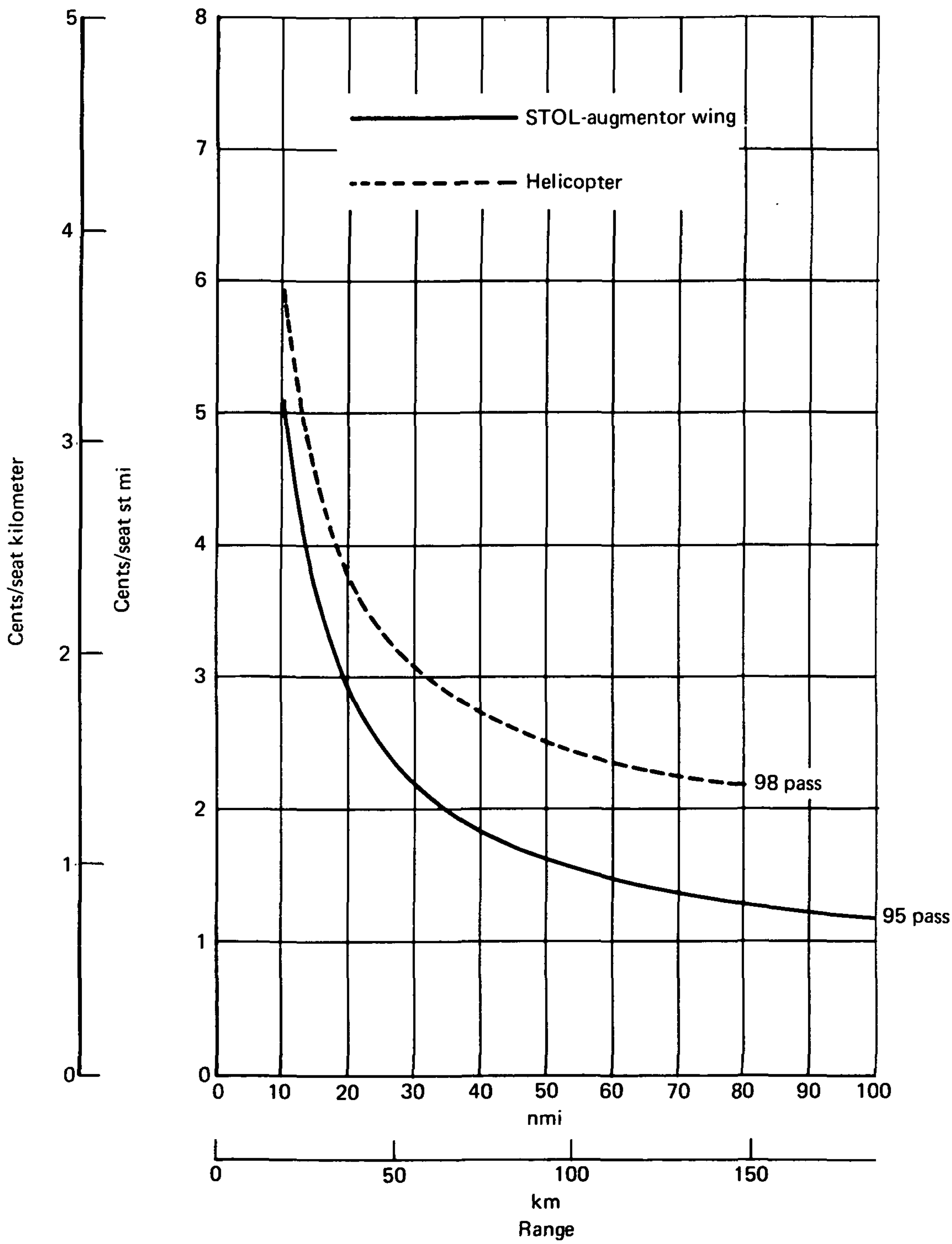


FIGURE 10-7.–CASH DIRECT OPERATING COST MINUS DEPRECIATION (1975)–CENTS/SEAT-MILE

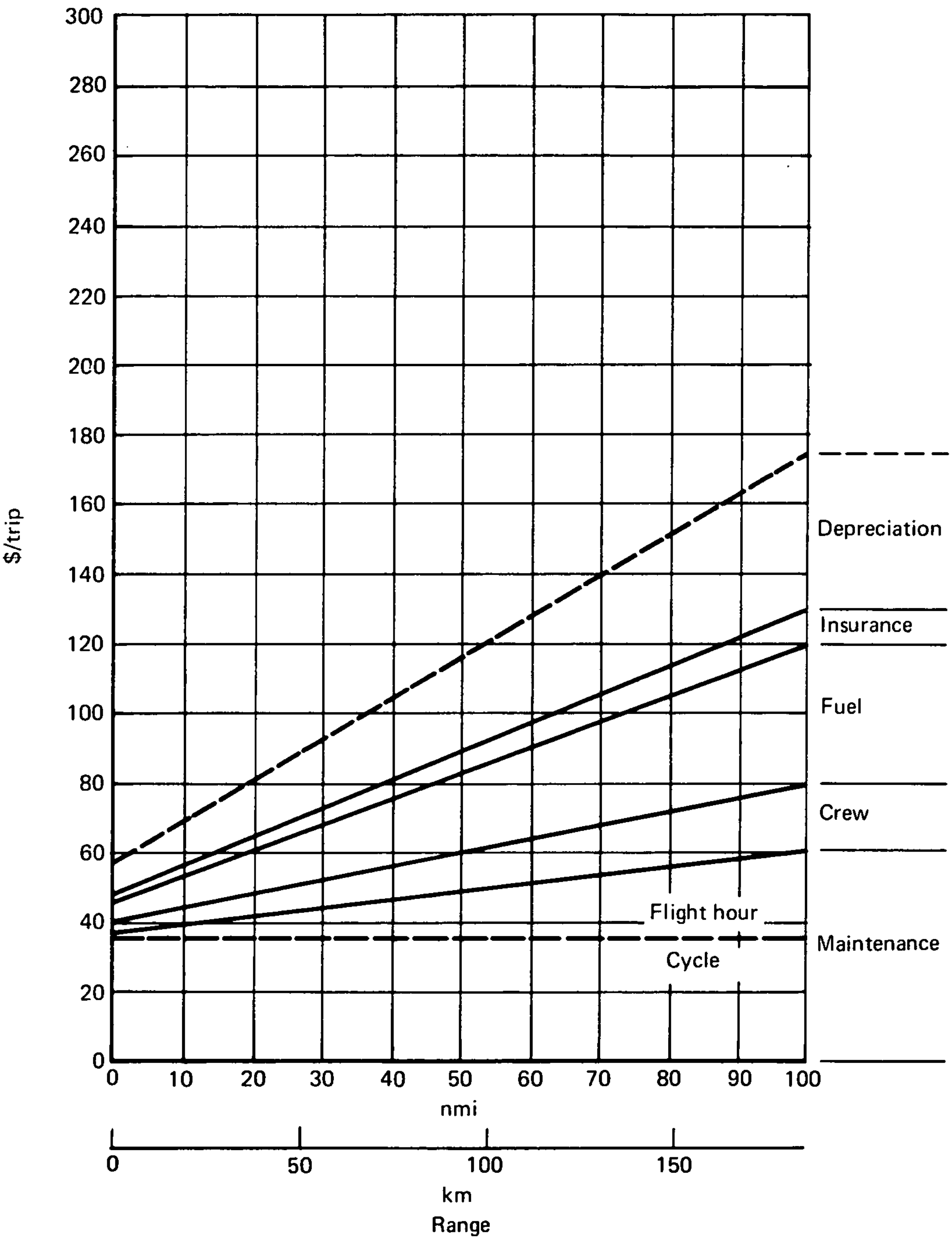


FIGURE 10-8.—CASH DIRECT OPERATING COST PLUS DEPRECIATION—AUGMENTOR WING STOL—95 PASSENGERS (1975)

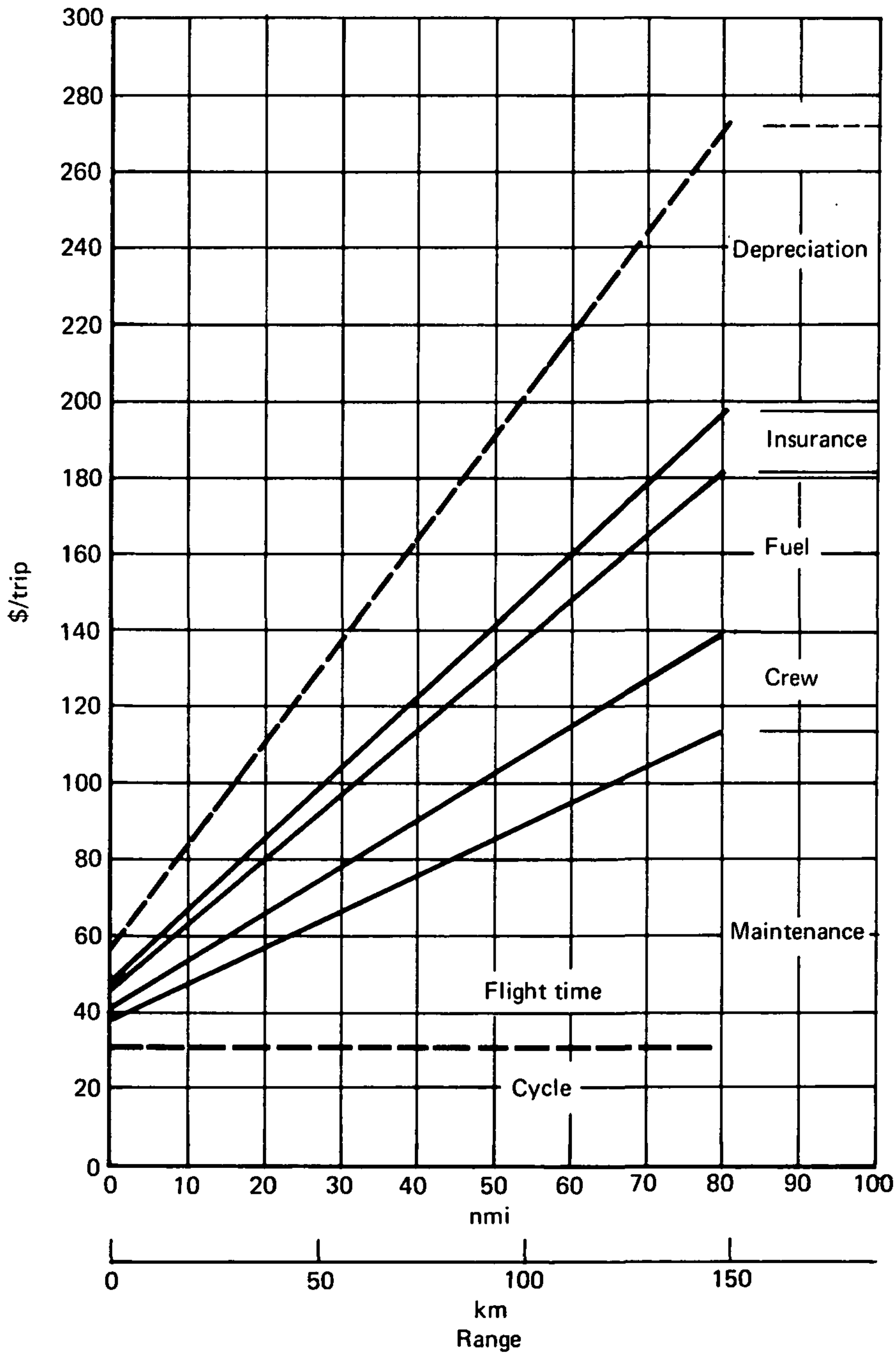


FIGURE 10-9.—CASH DIRECT OPERATING COST PLUS DEPRECIATION—HELICOPTER—98 PASSENGERS (1975)

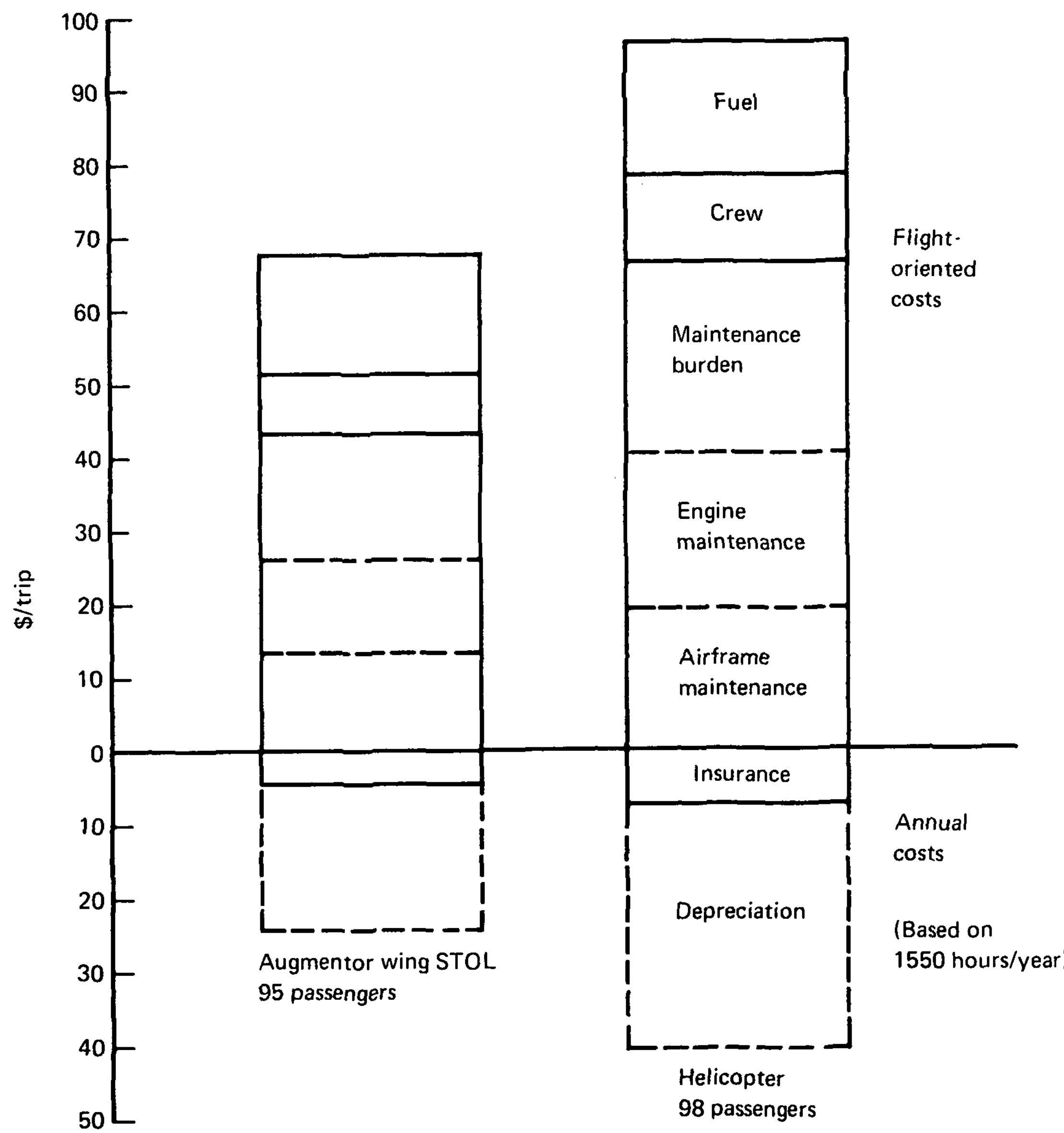
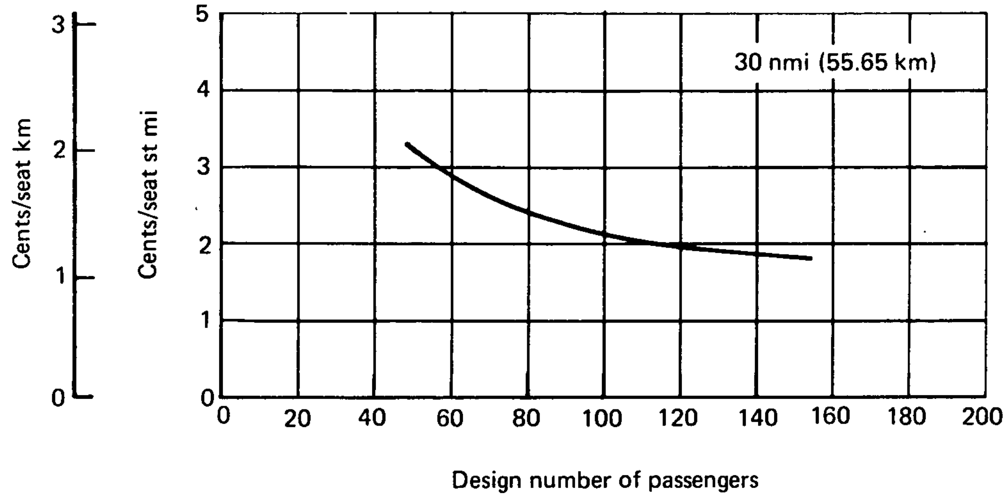


FIGURE 10-10.—CASH DIRECT OPERATING COST PLUS DEPRECIATION—30-NMI (55.5 KM) TRIP (1975)



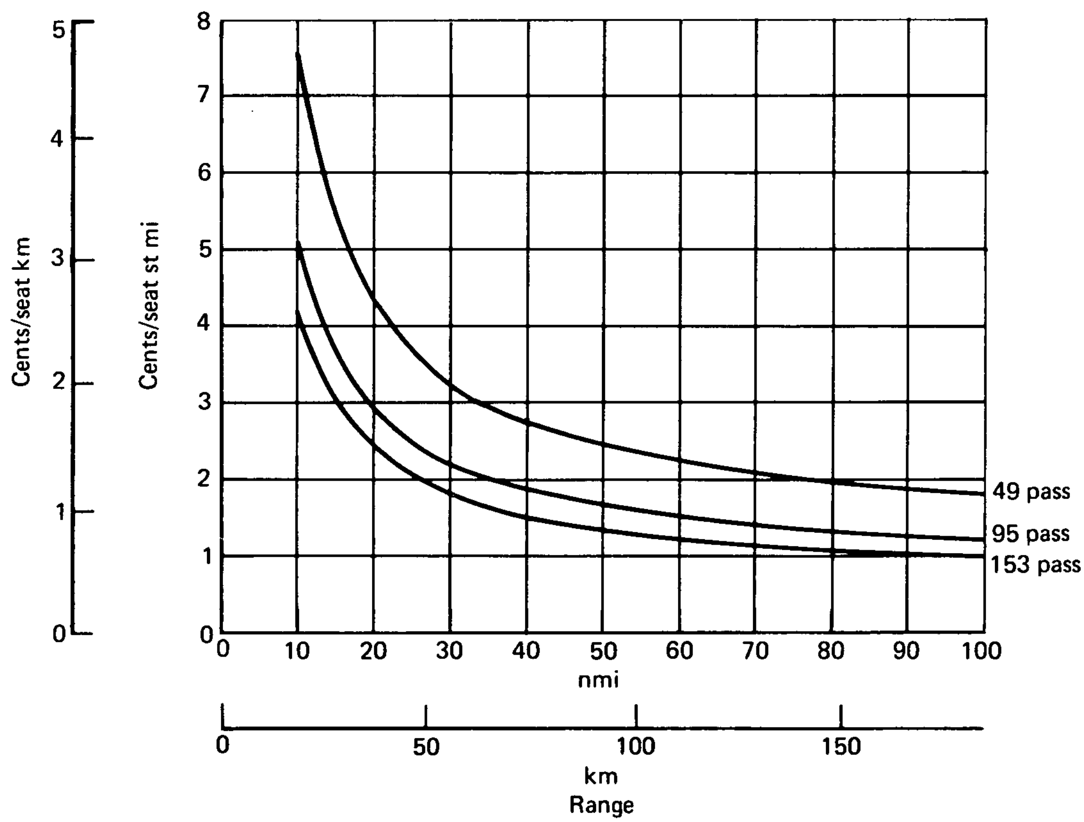


FIGURE 10-11.—CASH DIRECT OPERATING COST MINUS DEPRECIATION—AUGMENTOR WING STOL (1975)

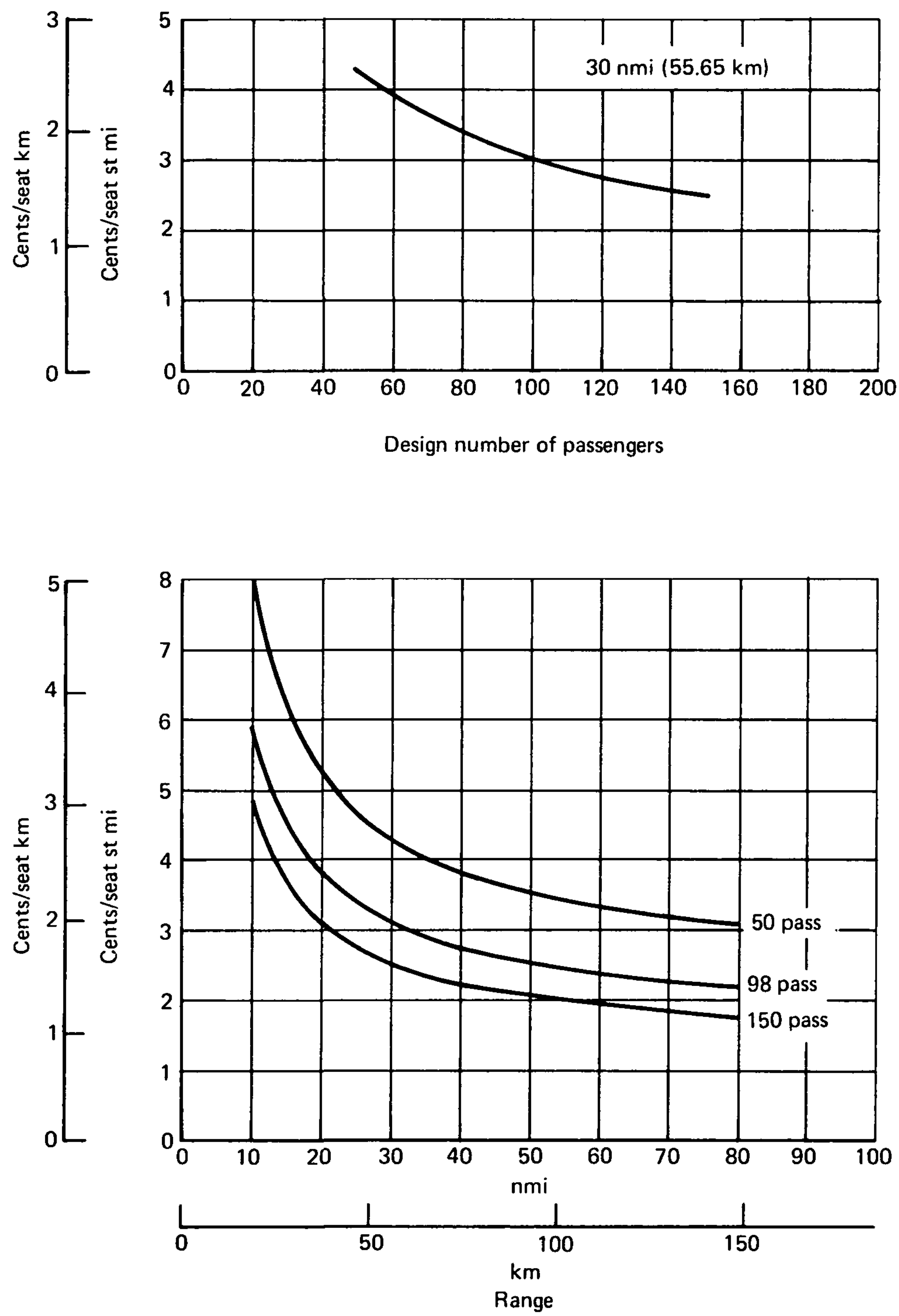


FIGURE 10-12.—CASH DIRECT OPERATING COST MINUS DEPRECIATION—HELICOPTER (1975)

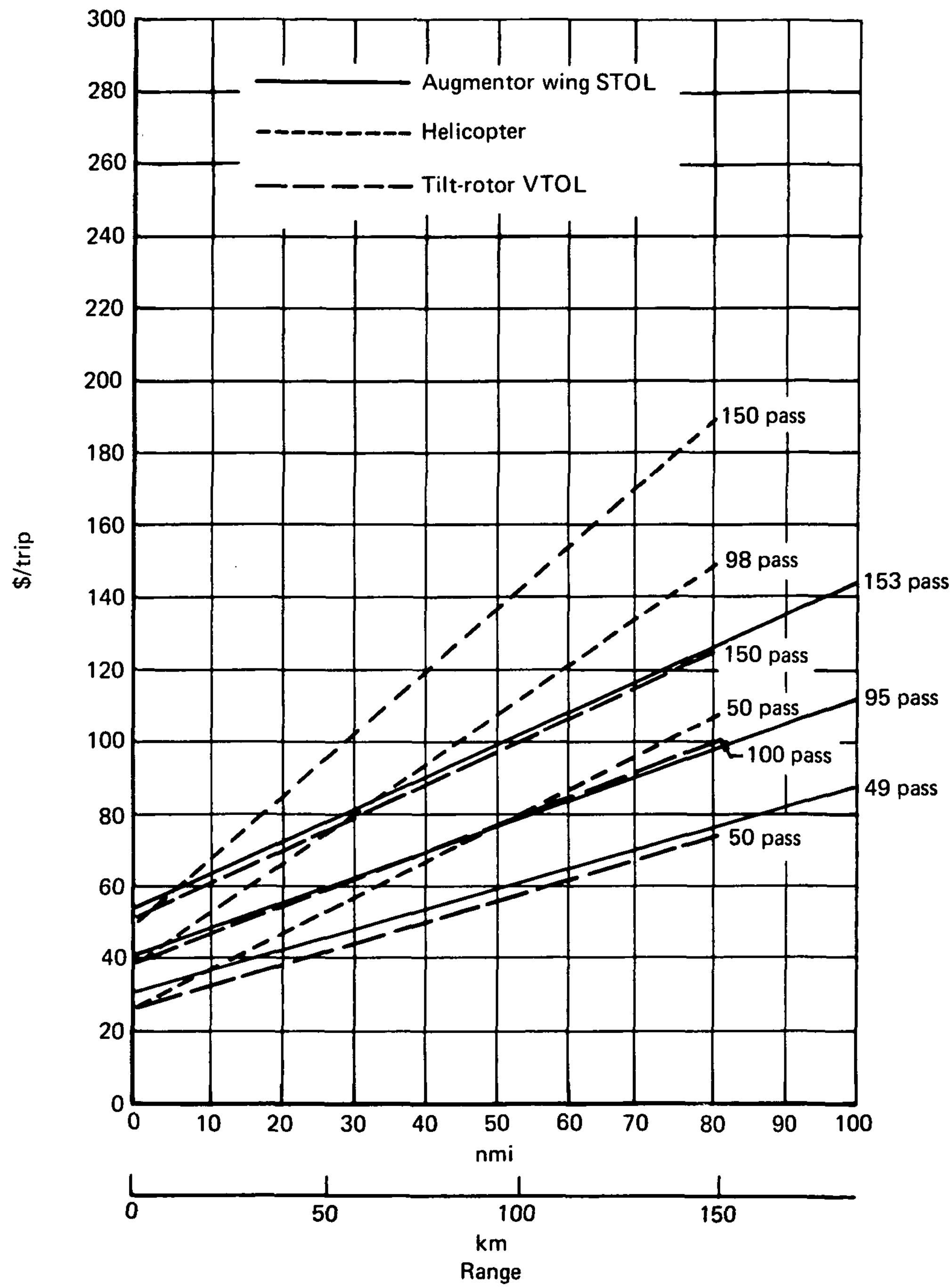


FIGURE 10-13.–CASH DIRECT OPERATING COST MINUS DEPRECIATION (1985)–$/TRIP

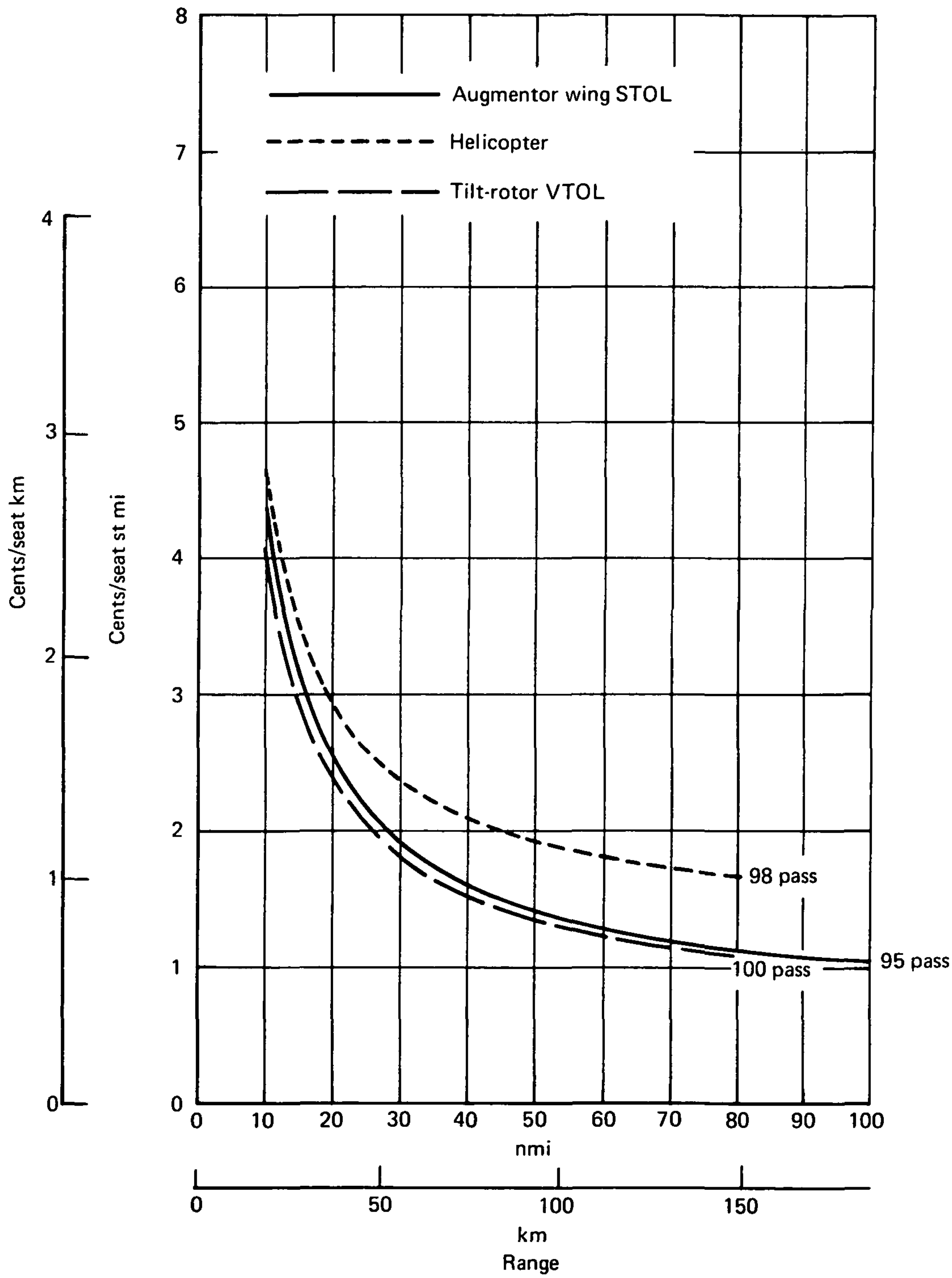


FIGURE 10-14.—CASH DIRECT OPERATING COST MINUS DEPRECIATION (1985)—CENTS/SEAT-MILE

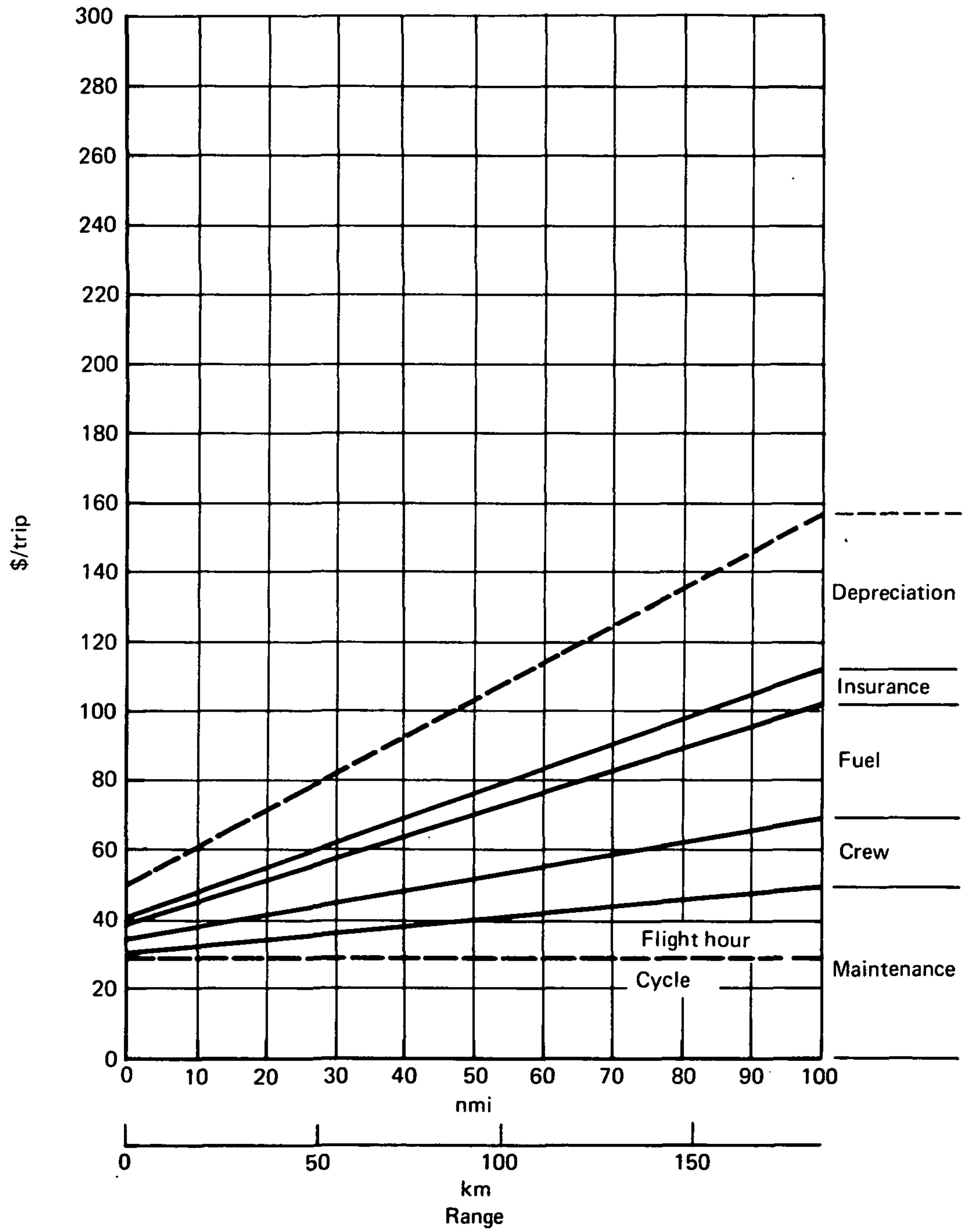


*FIGURE 10-15.–CASH DIRECT OPERATING COST PLUS DEPRECIATION–
AUGMENTOR WING STOL–95 PASSENGERS (1985)*

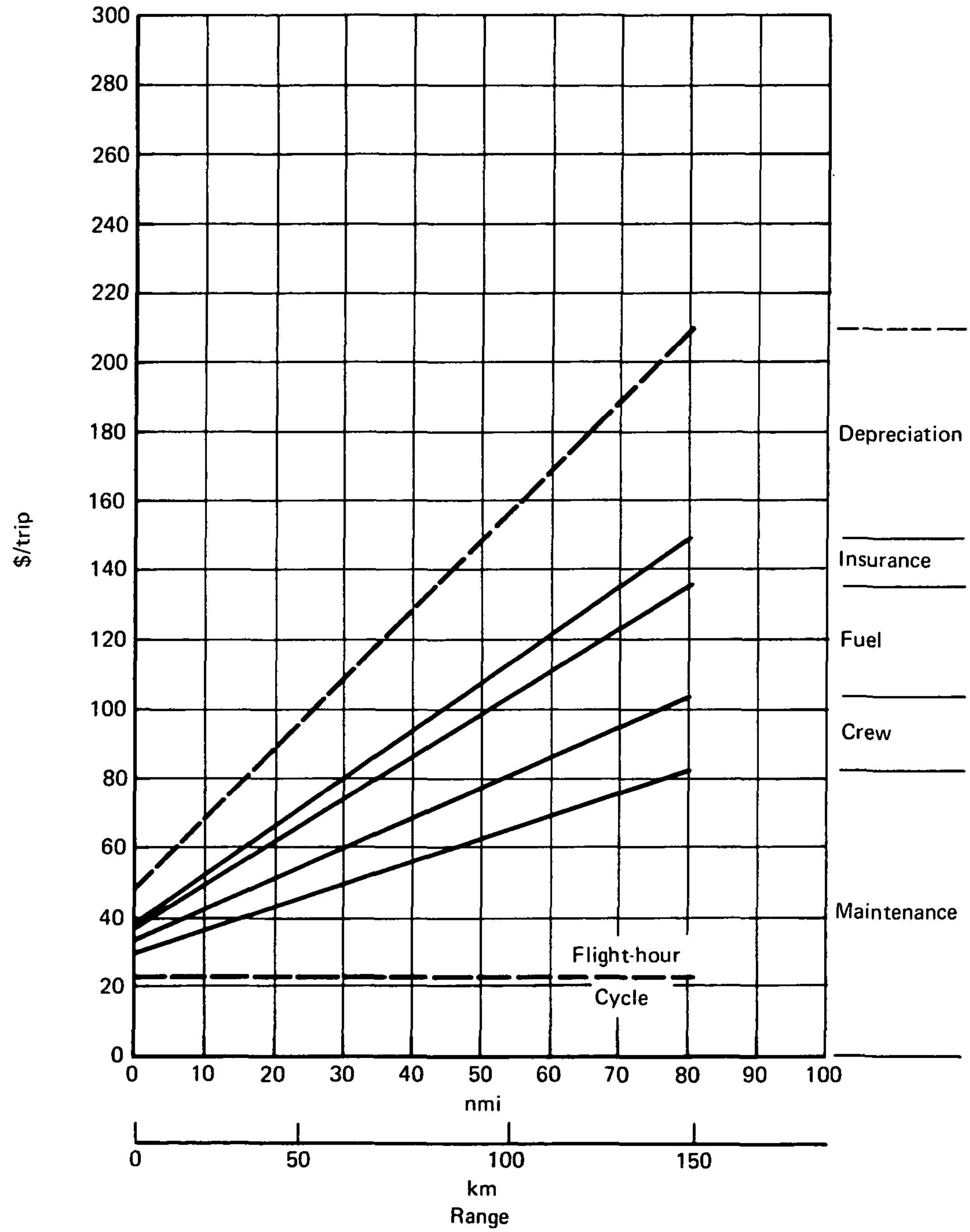


FIGURE 10-16.—CASH DIRECT OPERATING COST PLUS DEPRECIATION—HELICOPTER—98 PASSENGERS (1985)

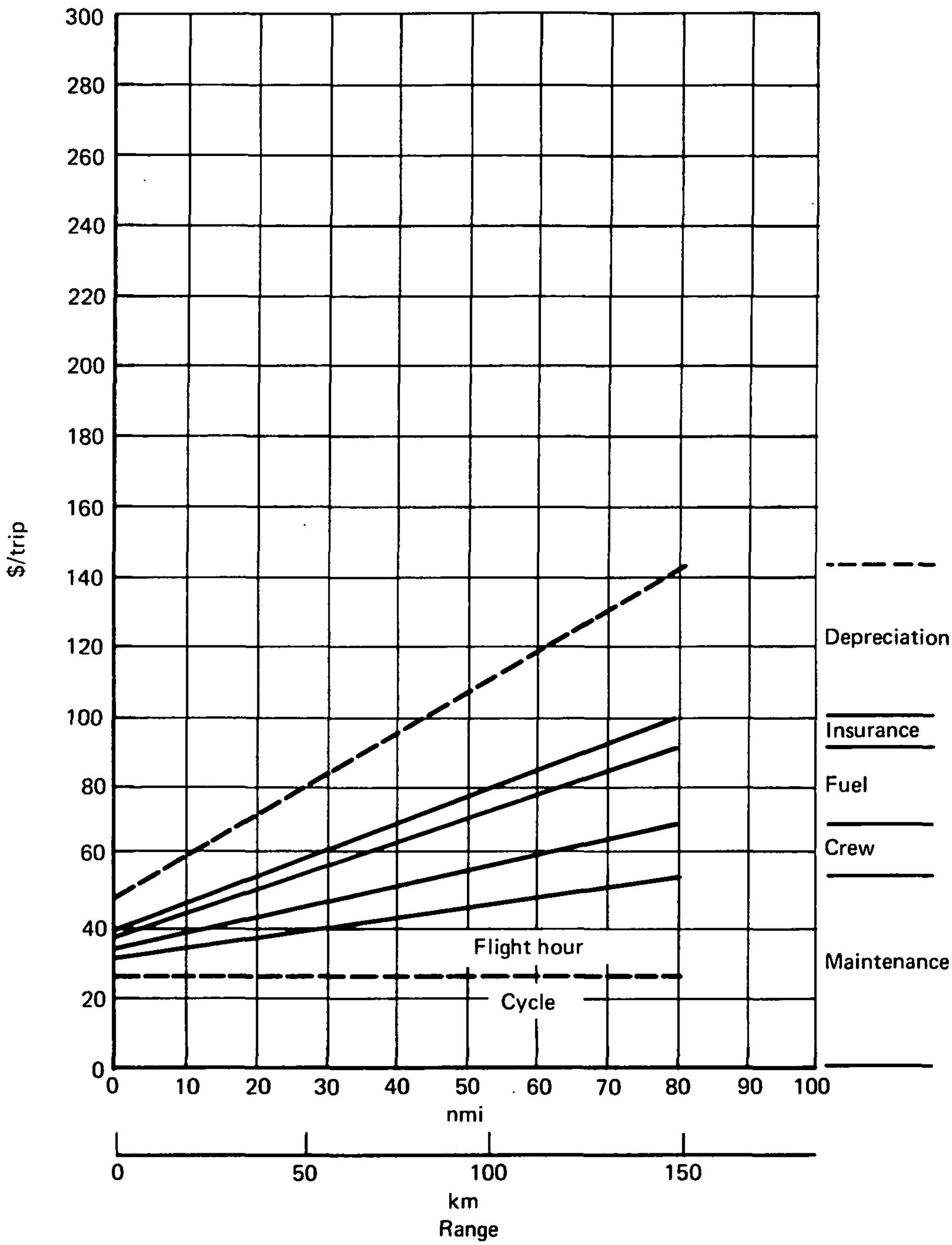


FIGURE 10-17.—CASH DIRECT OPERATING COST PLUS DEPRECIATION— TILT-ROTOR VTOL—100 PASSENGERS (1985)

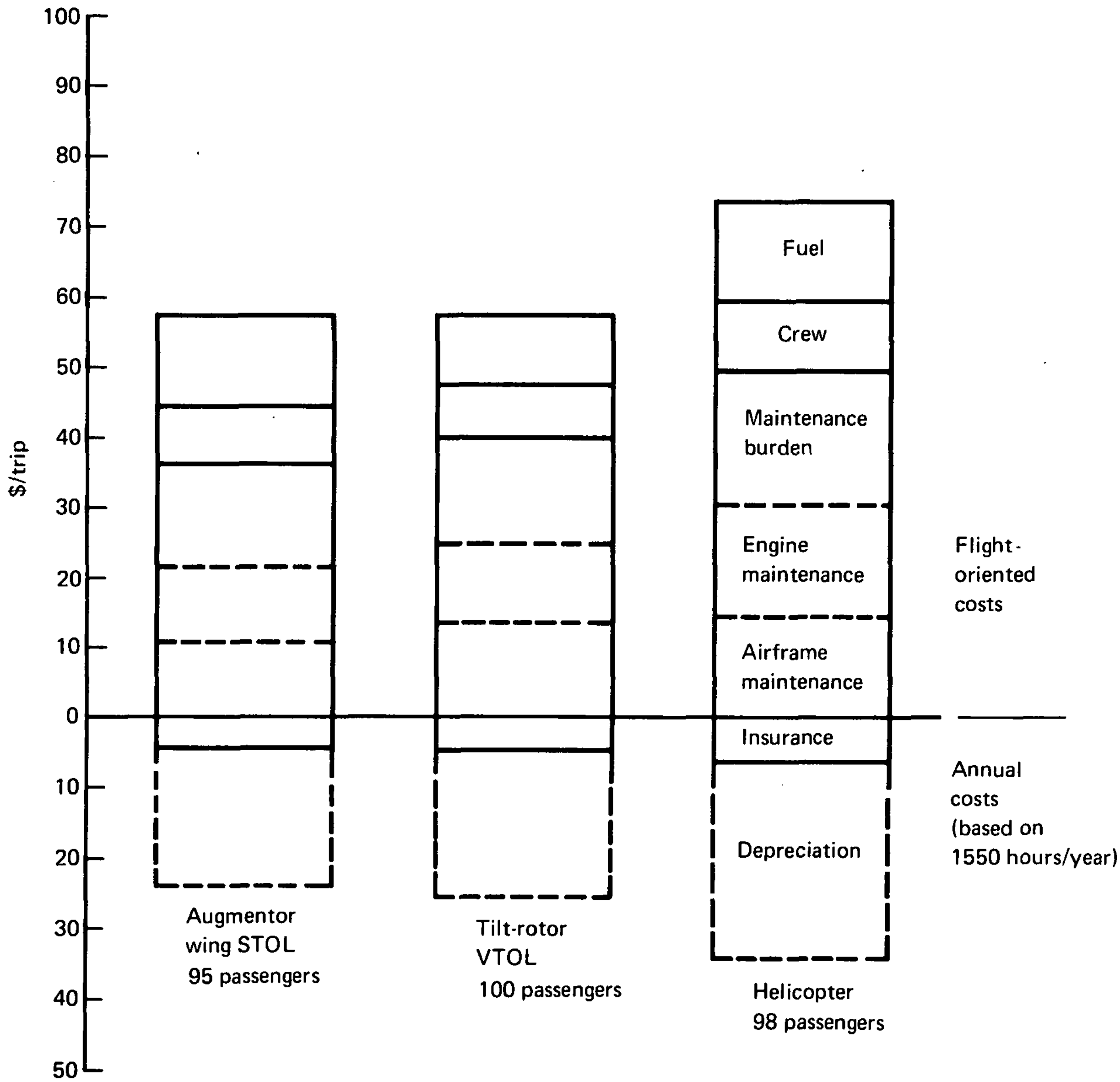


FIGURE 10-18.–CASH DIRECT OPERATING COST PLUS DEPRECIATION– 30-NMI (55.5 KM) TRIP (1985)

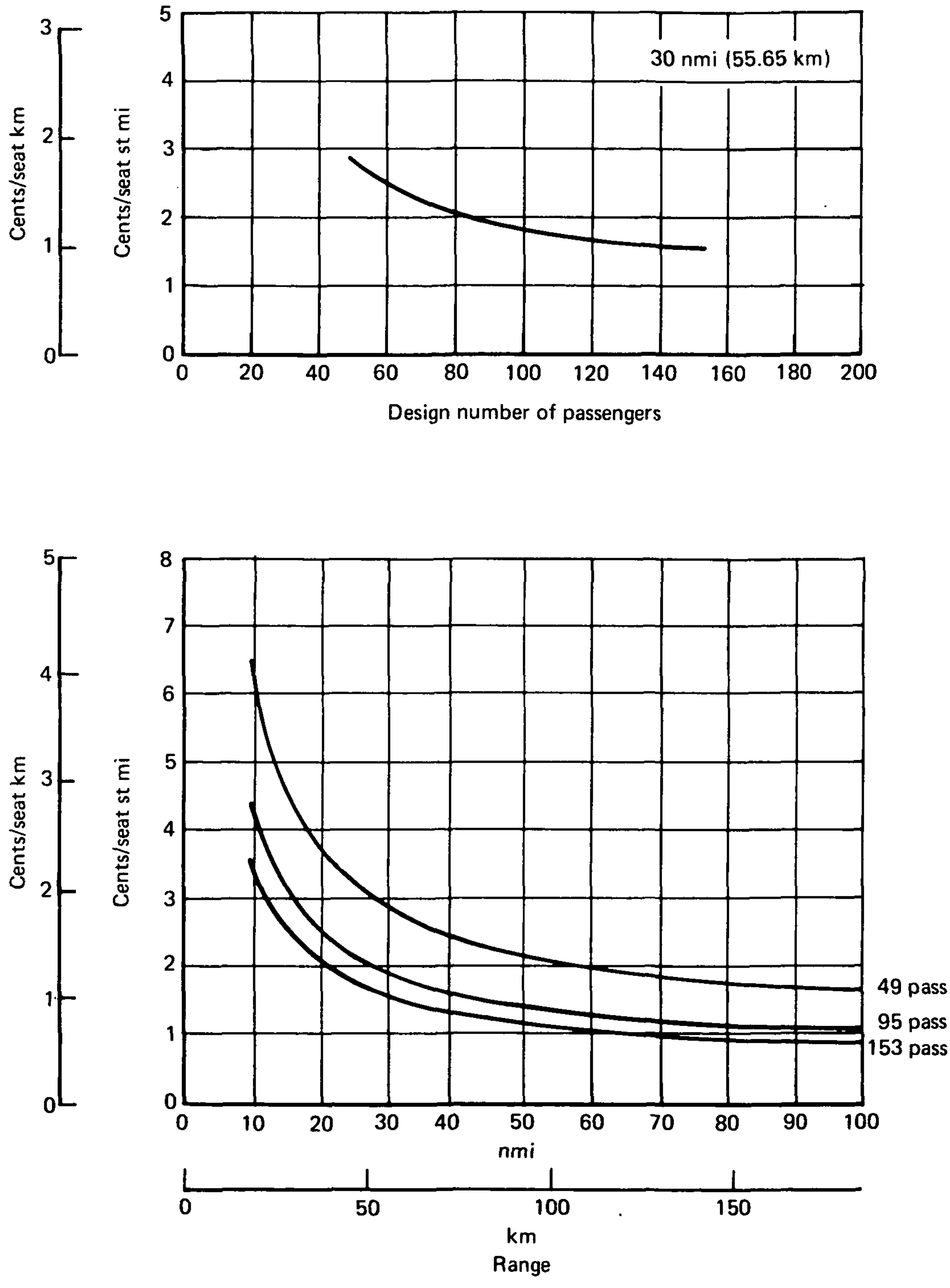


FIGURE 10-19.—CASH DIRECT OPERATING COST MINUS DEPRECIATION—AUGMENTOR WING STOL (1985)

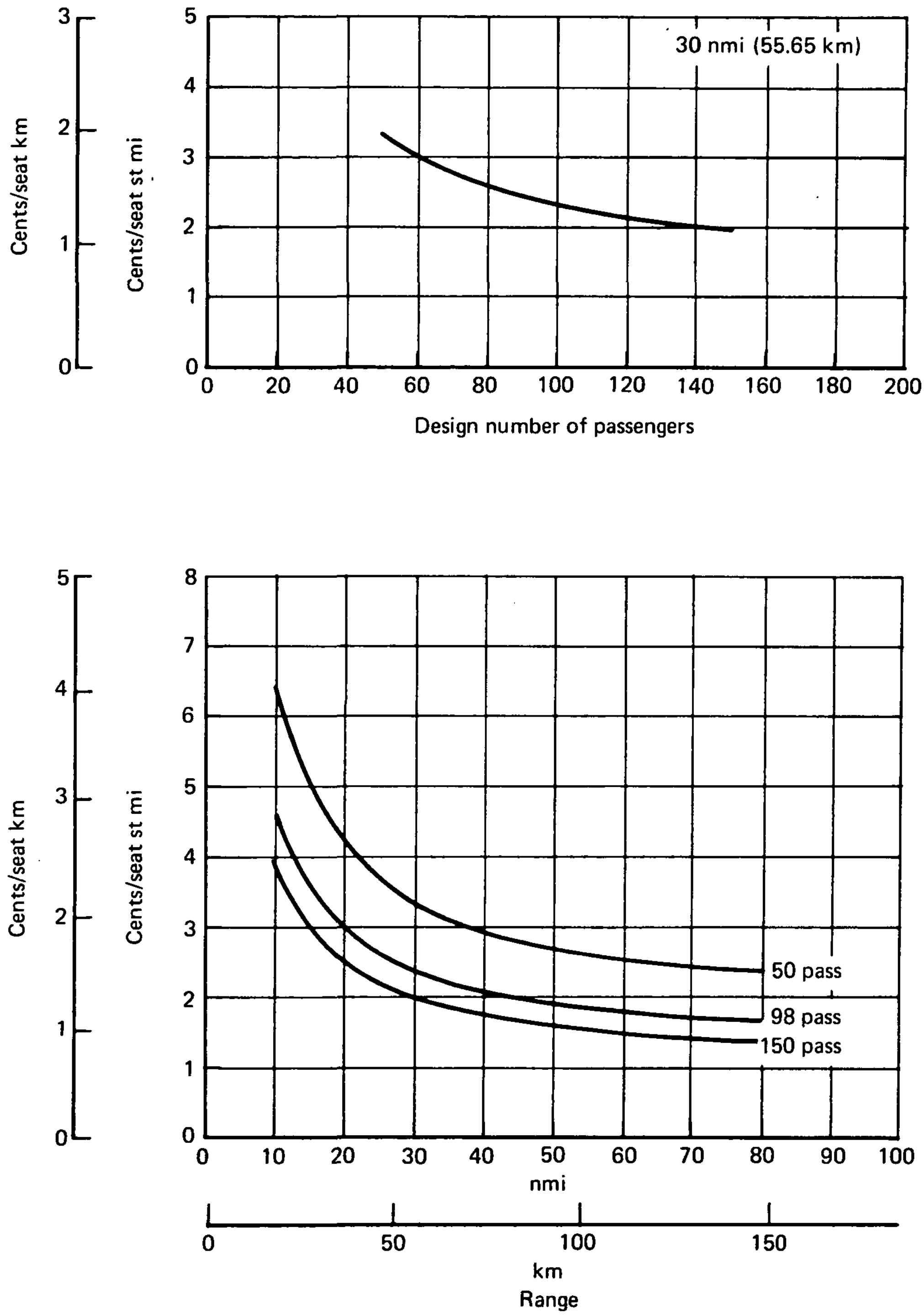


FIGURE 10-20.–CASH DIRECT OPERATING COST MINUS DEPRECIATION–HELICOPTER (1985)

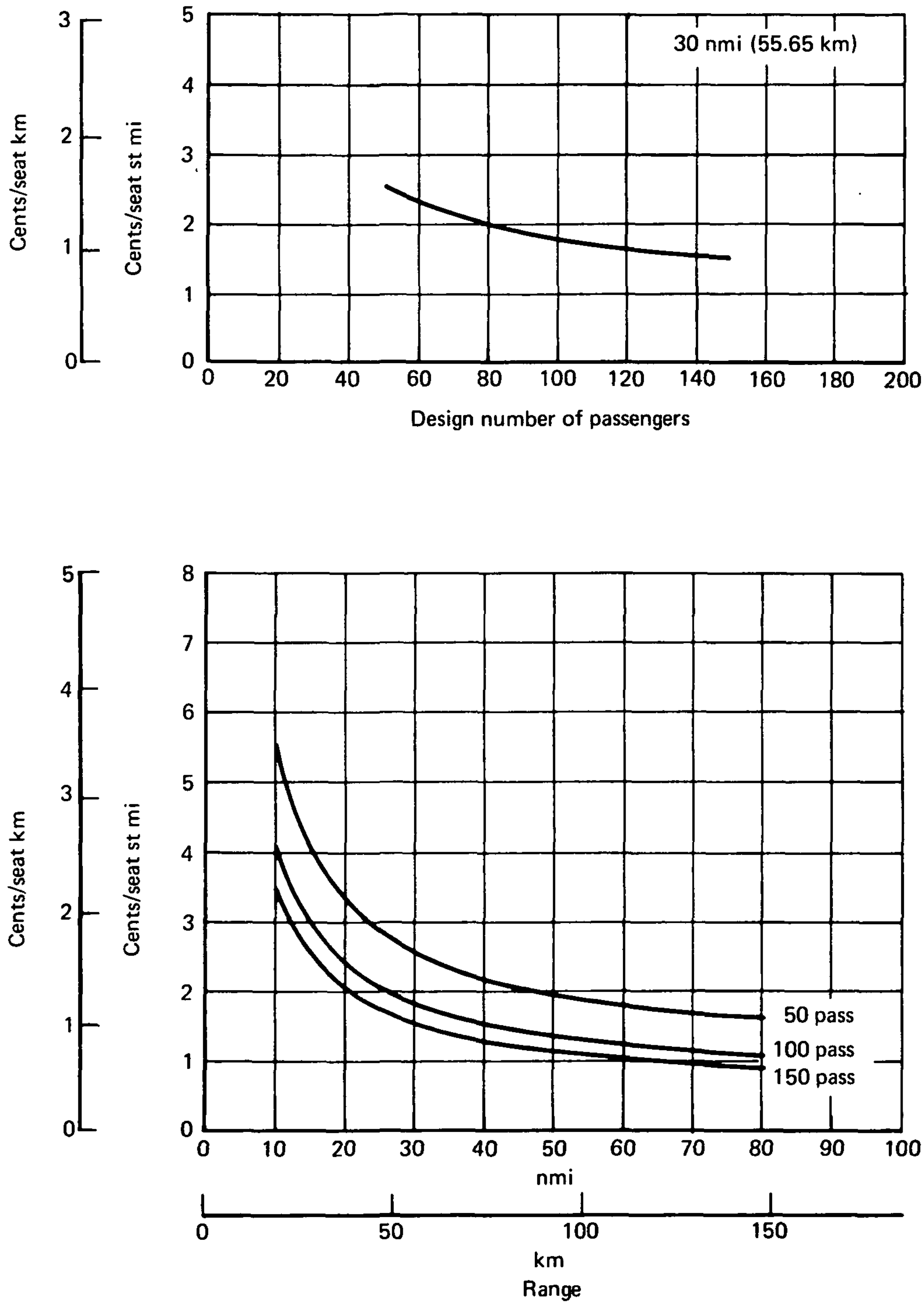


FIGURE 10-21.—CASH DIRECT OPERATING COST MINUS DEPRECIATION—TILT-ROTOR VTOL (1985)

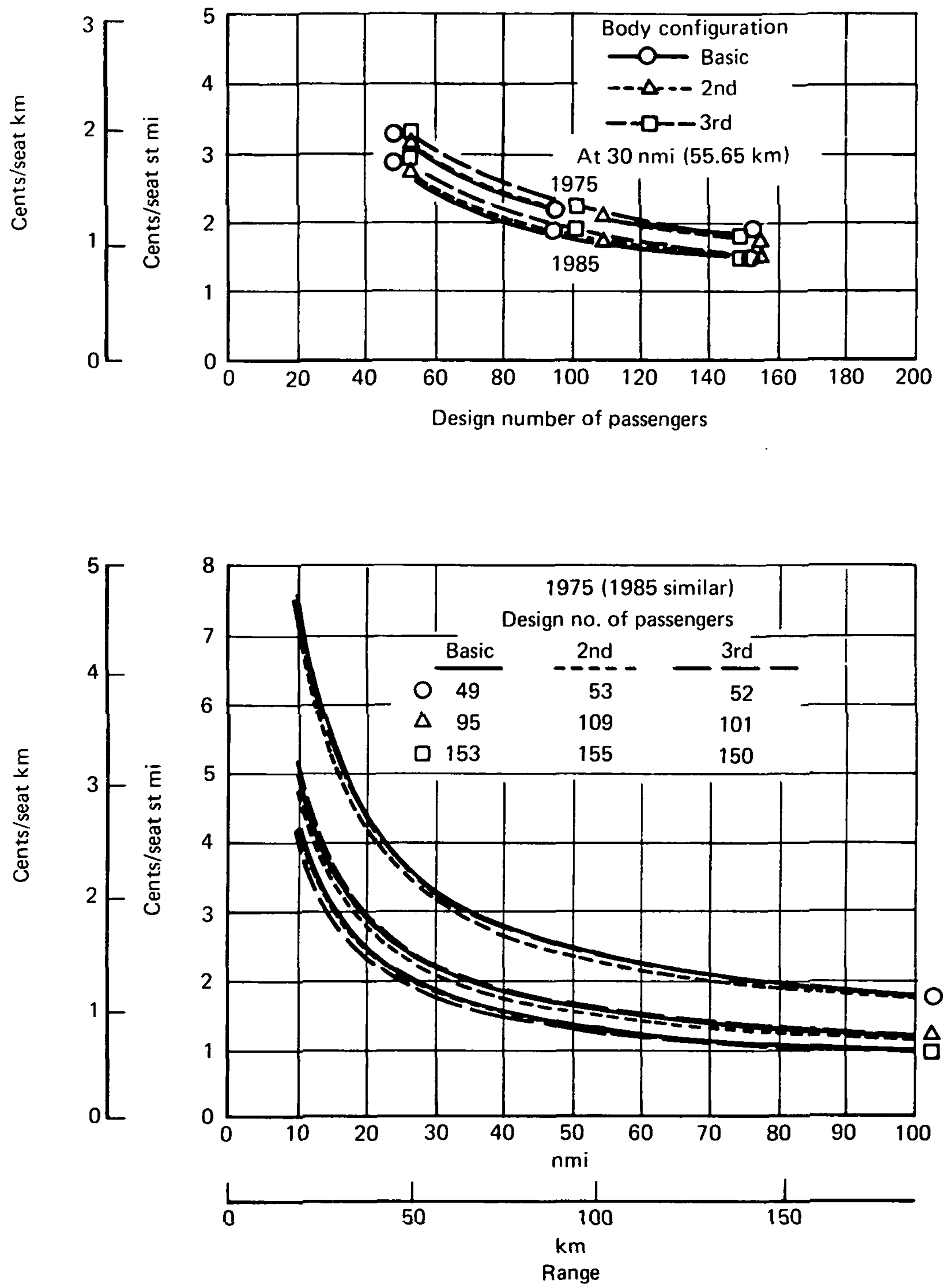


FIGURE 10-22.—CASH DIRECT OPERATING COST MINUS DEPRECIATION—AUGMENTOR WING STOL

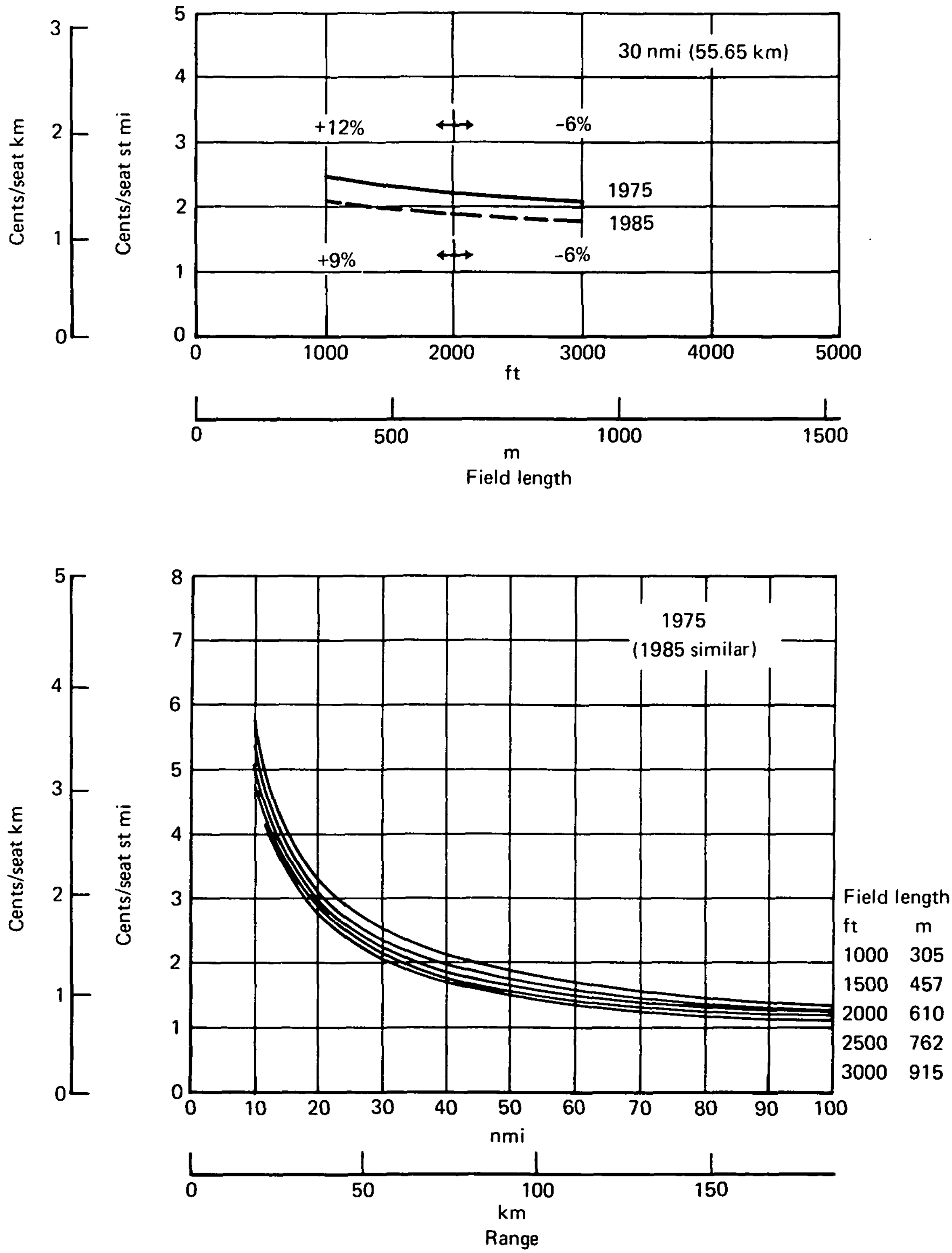
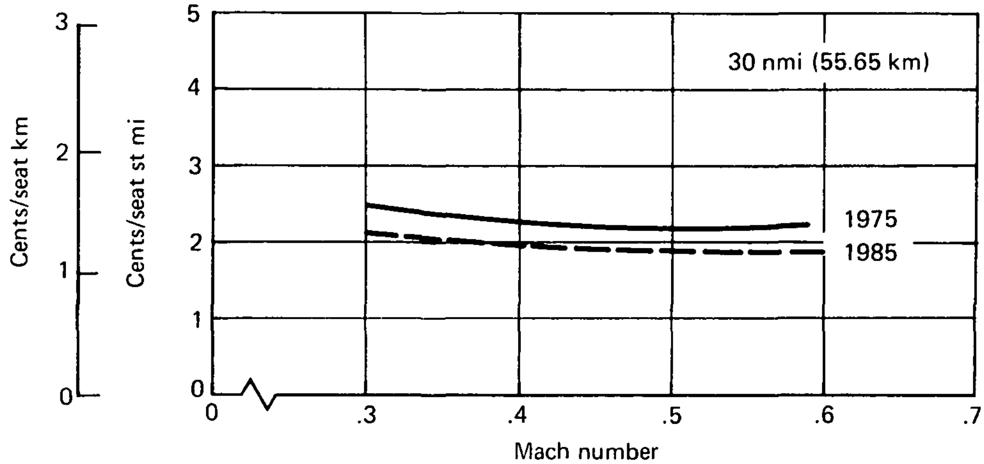


FIGURE 10-23.–CASH DIRECT OPERATING COST MINUS DEPRECIATION–TAKEOFF FIELD LENGTH SENSITIVITY–AUGMENTOR WING STOL–95 PASSENGERS



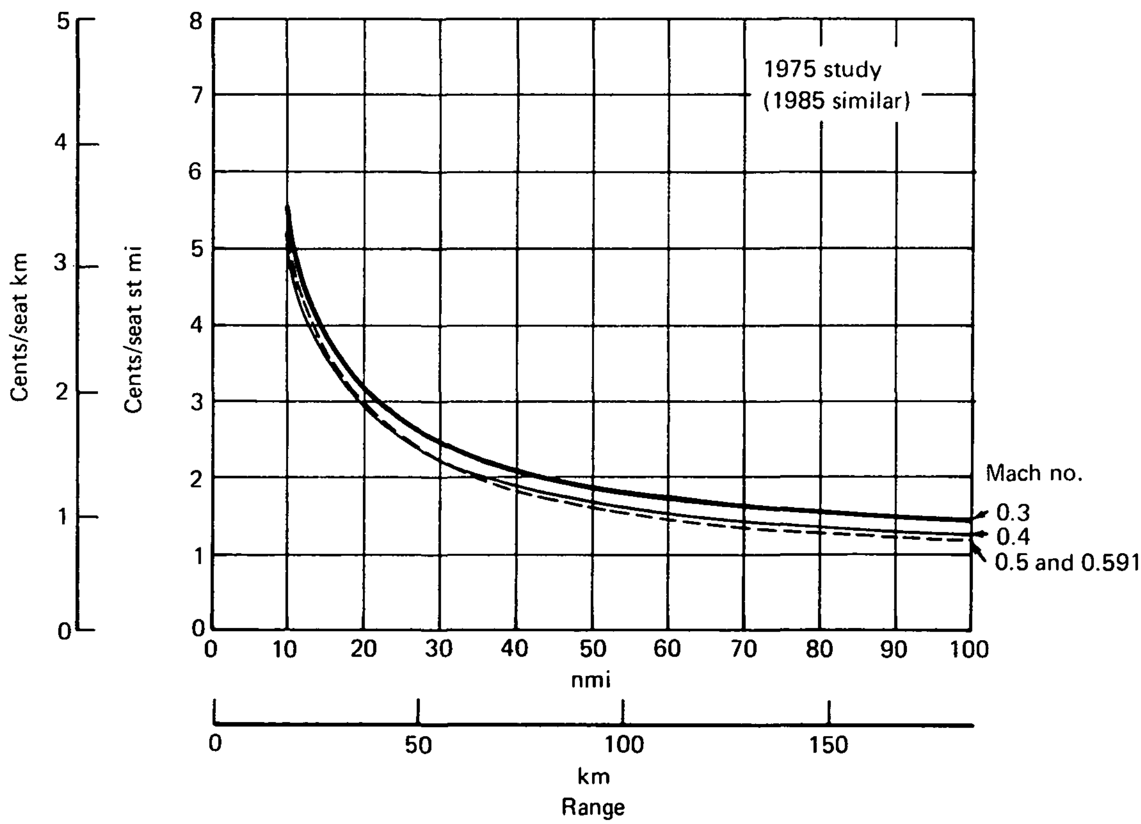


FIGURE 10-24.—CASH DIRECT OPERATING COST MINUS DEPRECIATION—MINIMUM COST CRUISE SPEED STUDY—AUGMENTOR WING STOL—95 PASSENGERS

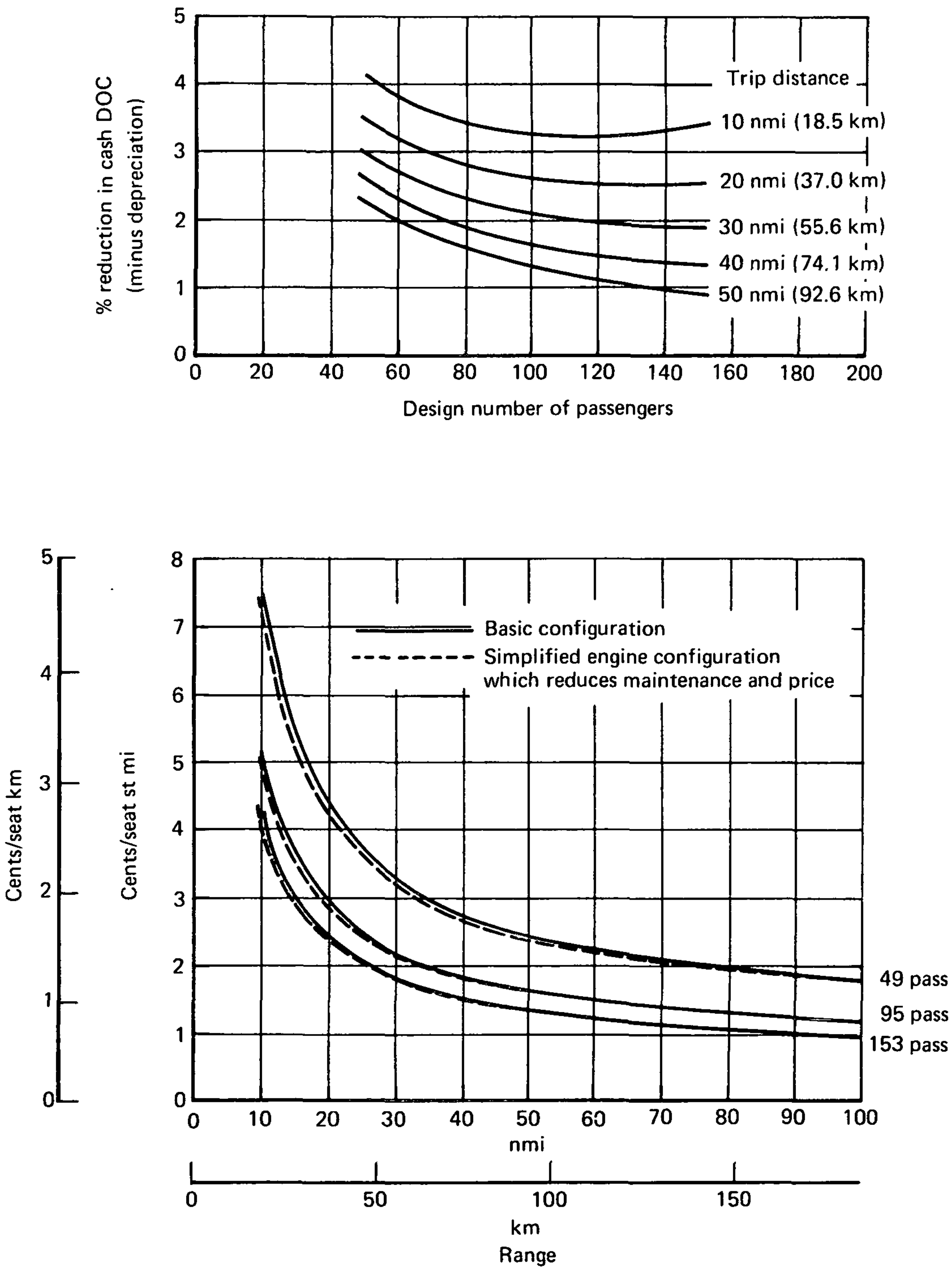


FIGURE 10-25.–CASH DIRECT OPERATING COST MINUS DEPRECIATION–SIMPLIFIED ENGINE SENSITIVITY–AUGMENTOR WING STOL (1975)

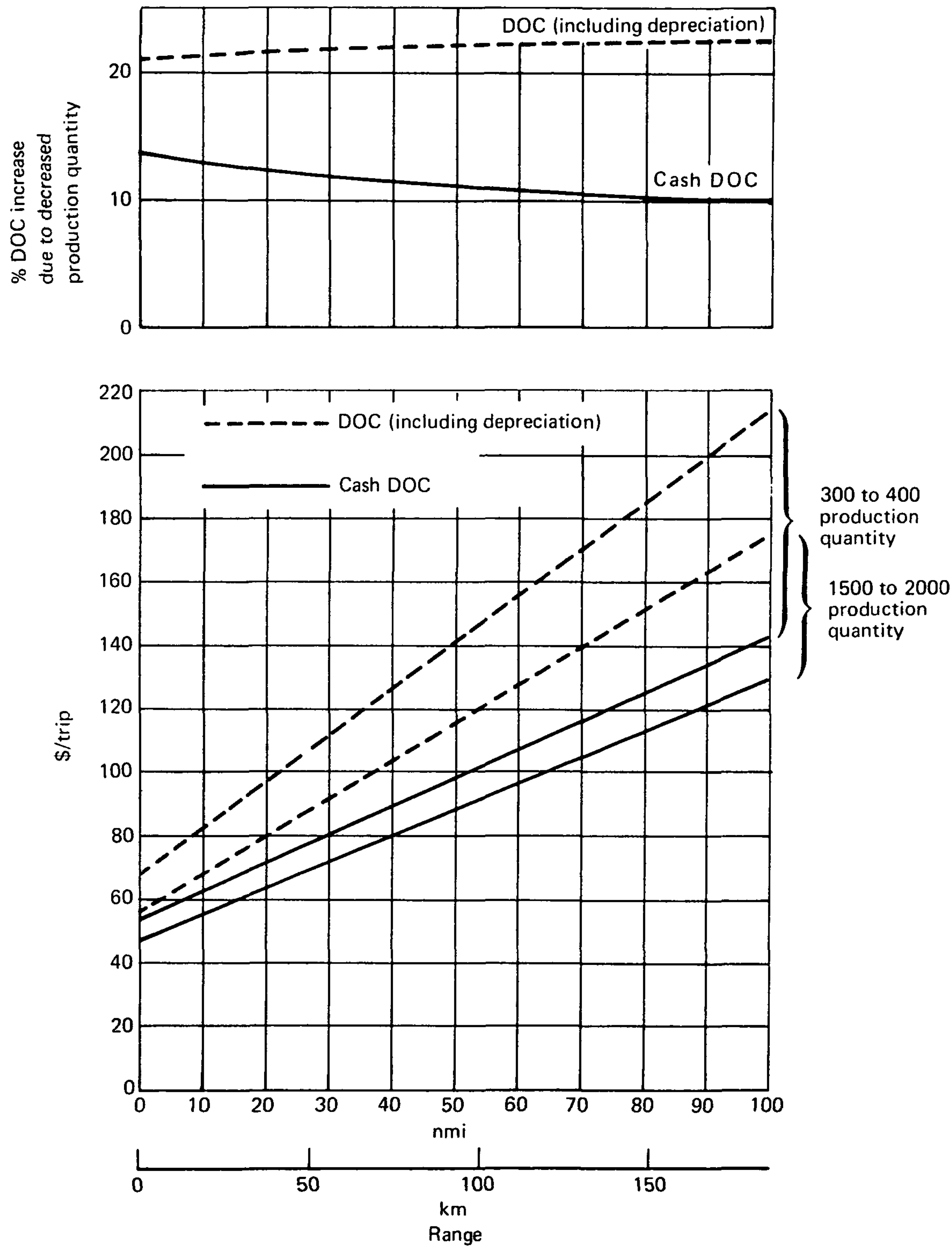
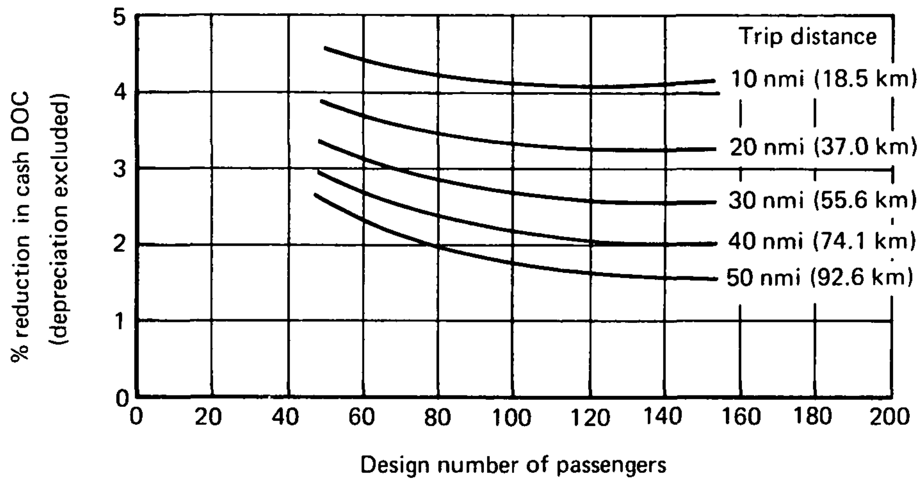


FIGURE 10-26.—CASH DIRECT OPERATING COST PLUS DEPRECIATION PRODUCTION QUANTITY SENSITIVITY—AUGMENTOR WING STOL—95 PASSENGERS (1975)



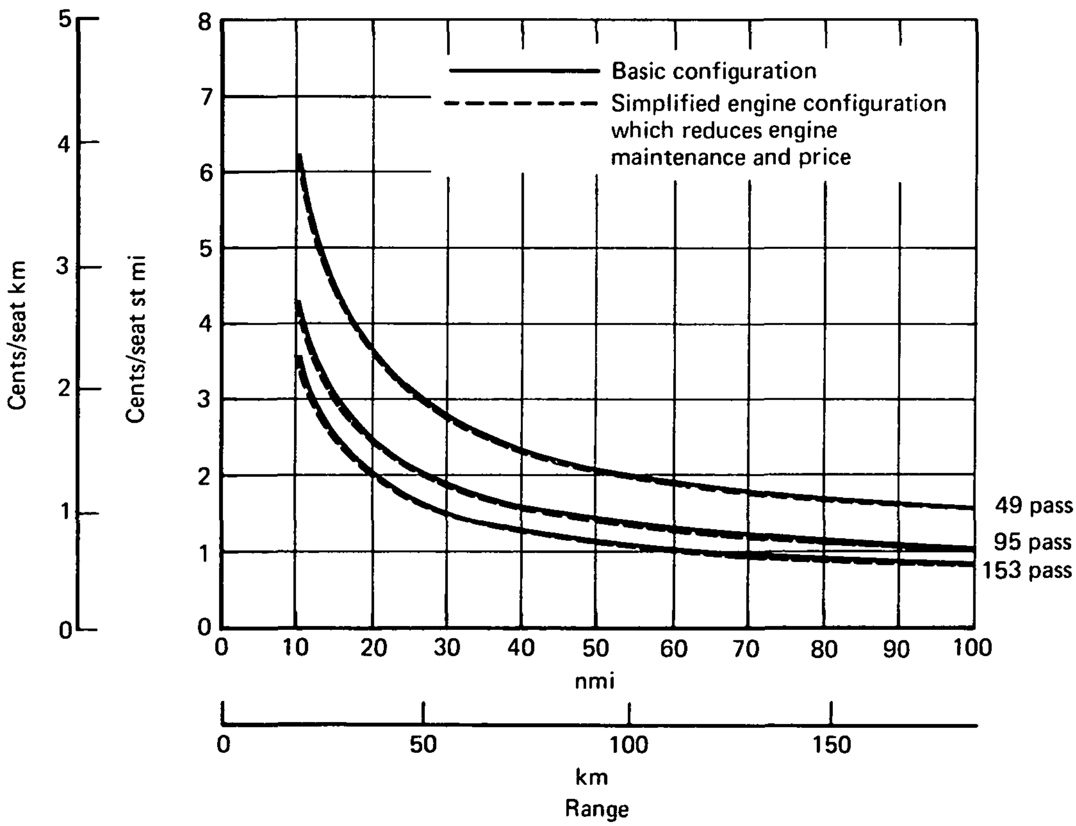


FIGURE 10-27.—CASH DIRECT OPERATING COST MINUS DEPRECIATION—SIMPLIFIED ENGINE SENSITIVITY—AUGMENTOR WING STOL (1985)

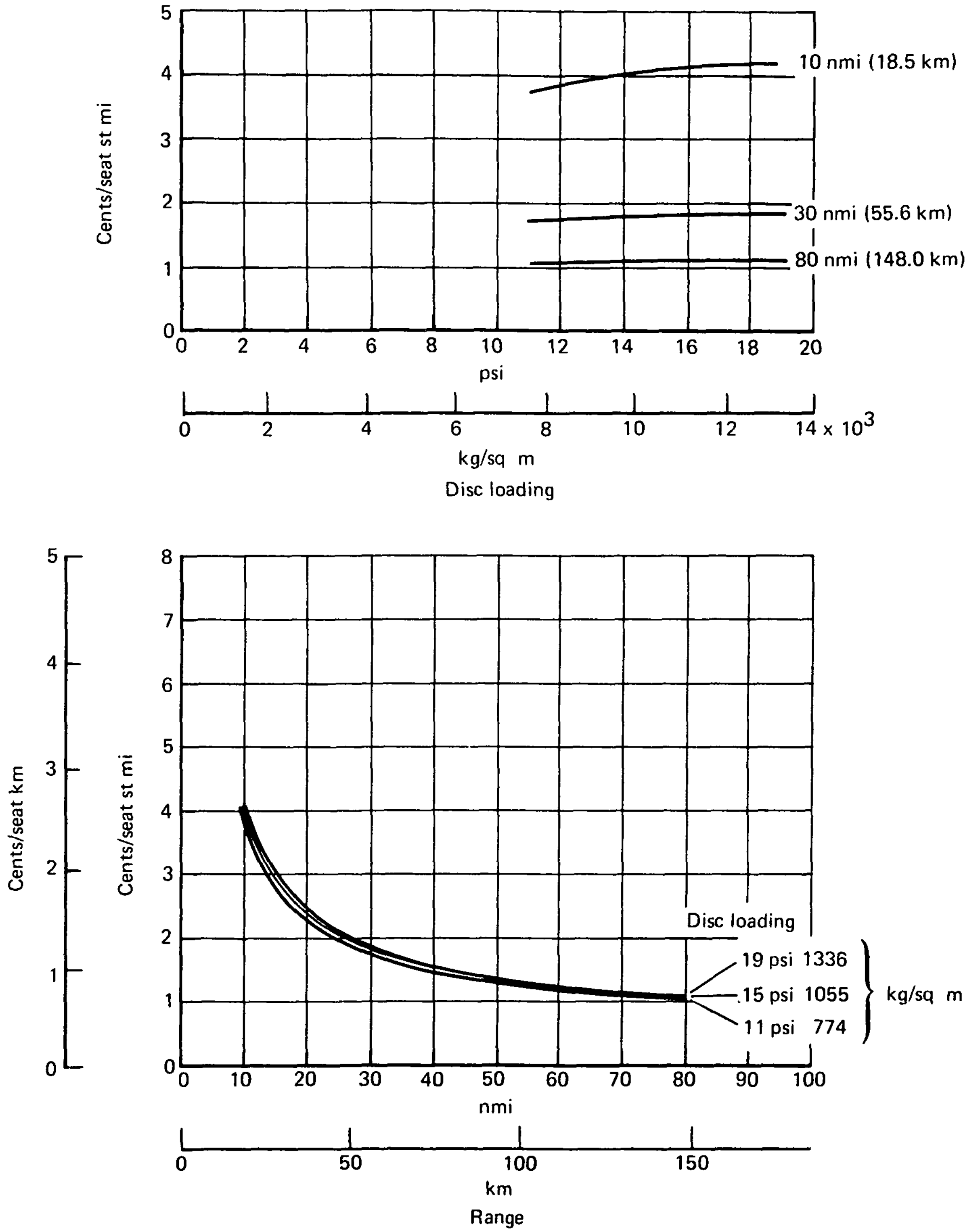


FIGURE 10-28.–CASH DIRECT OPERATING COST MINUS DEPRECIATION–DISC LOADING SENSITIVITY–TILT-ROTOR VTOL–100 PASENGERS (1985)

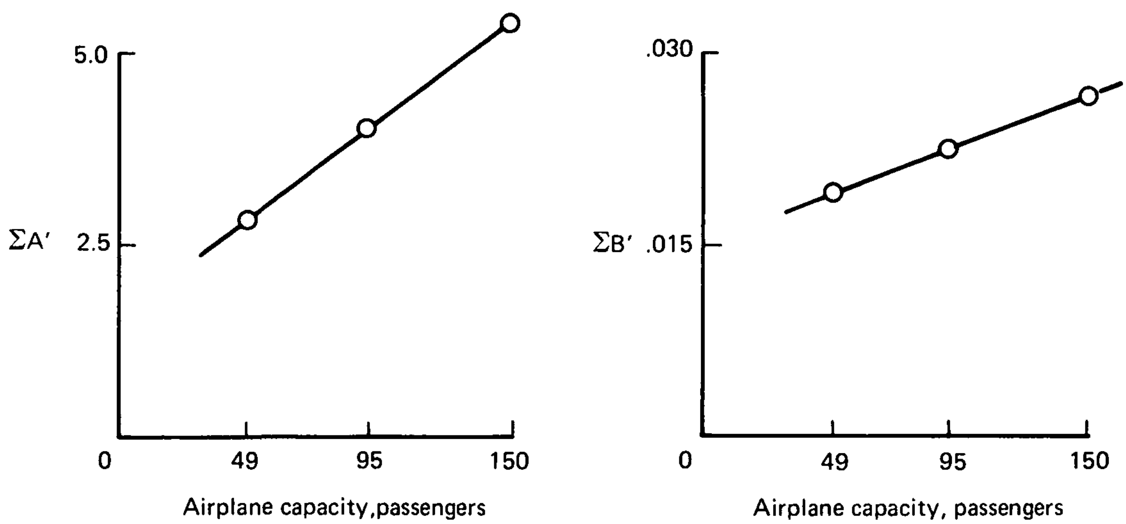


FIGURE 10-29.—IOC COEFFICIENTS

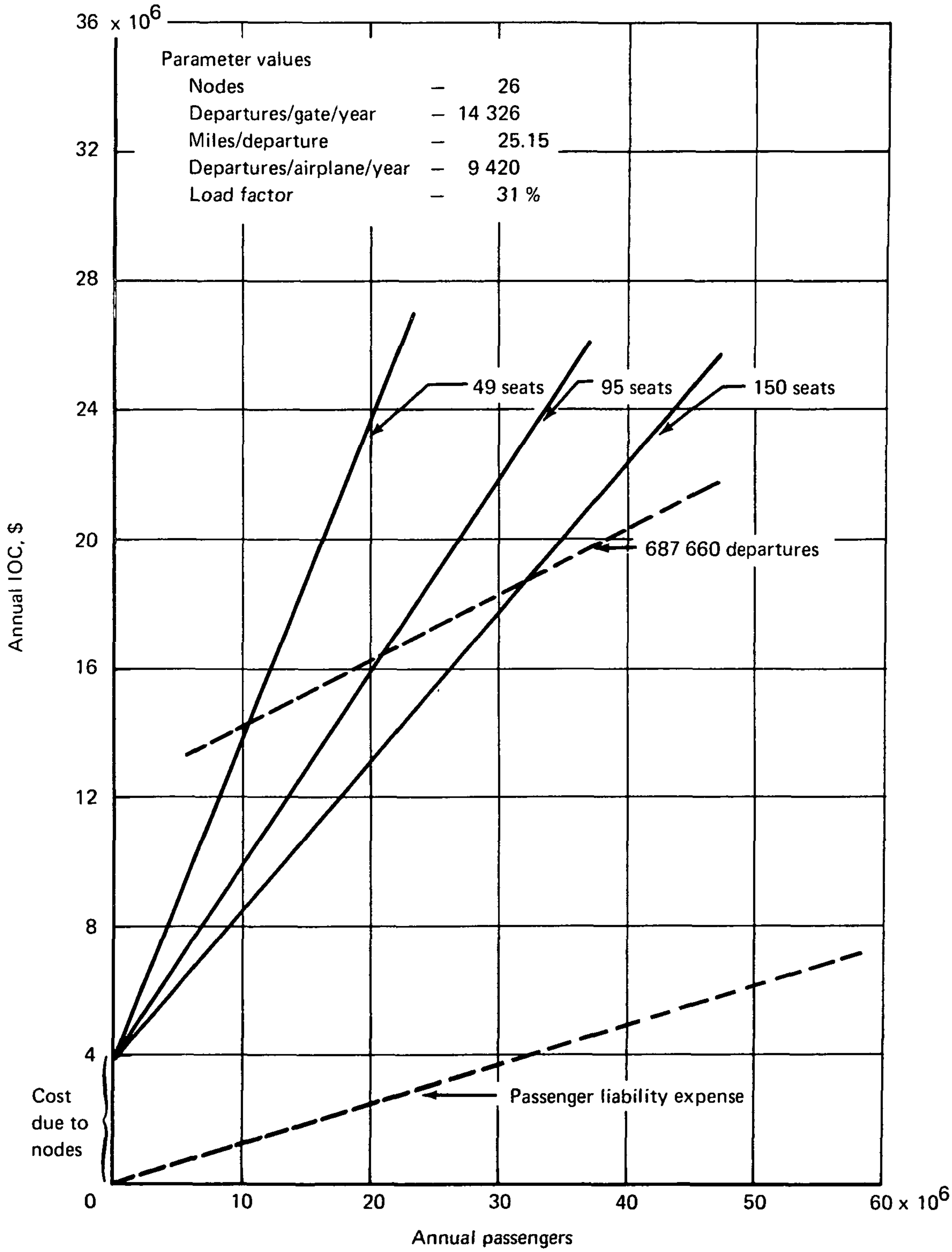


FIGURE 10-30.– IOC TRENDS 31% LOAD FACTOR

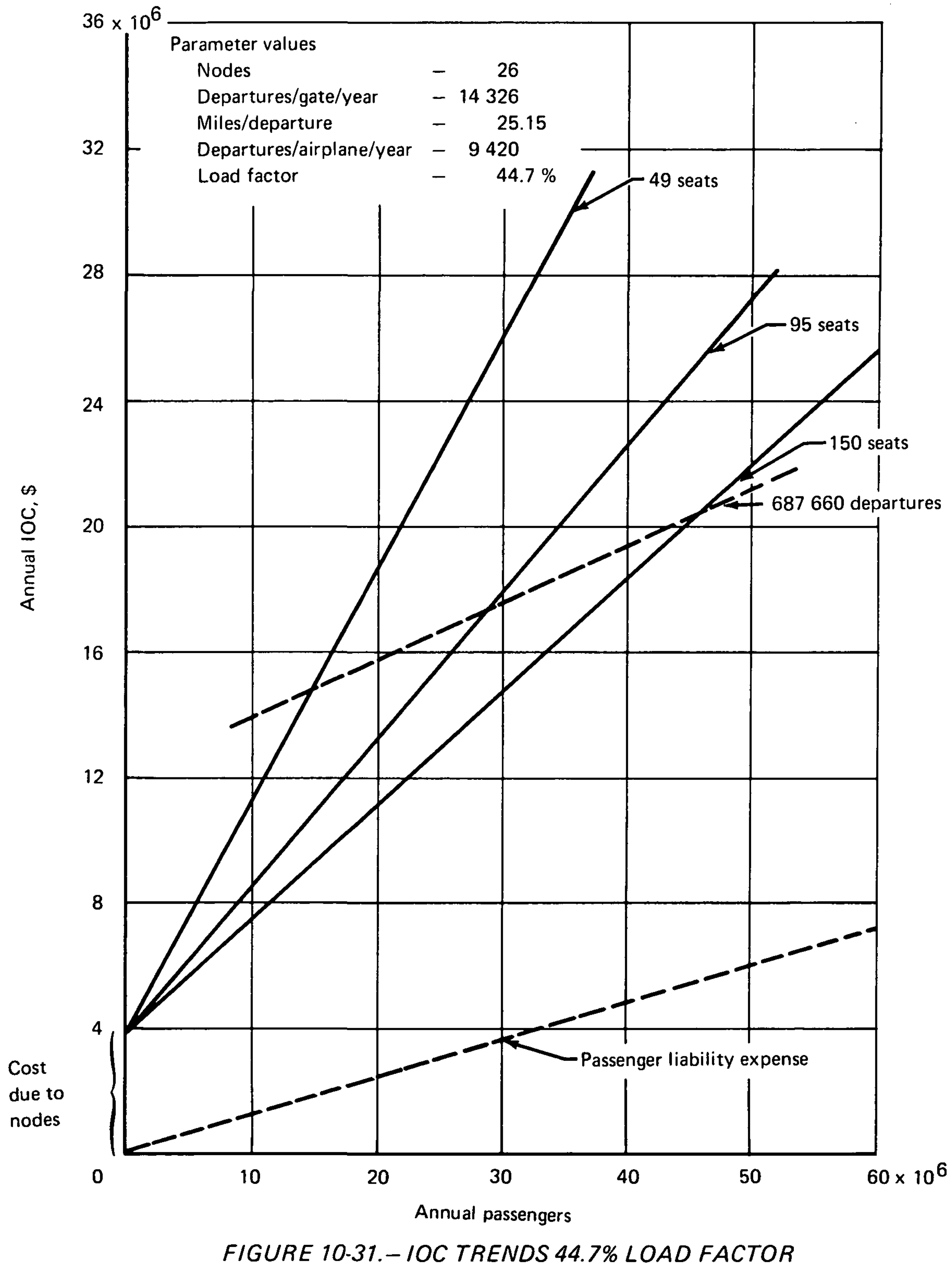


FIGURE 10-31.– IOC TRENDS 44.7% LOAD FACTOR

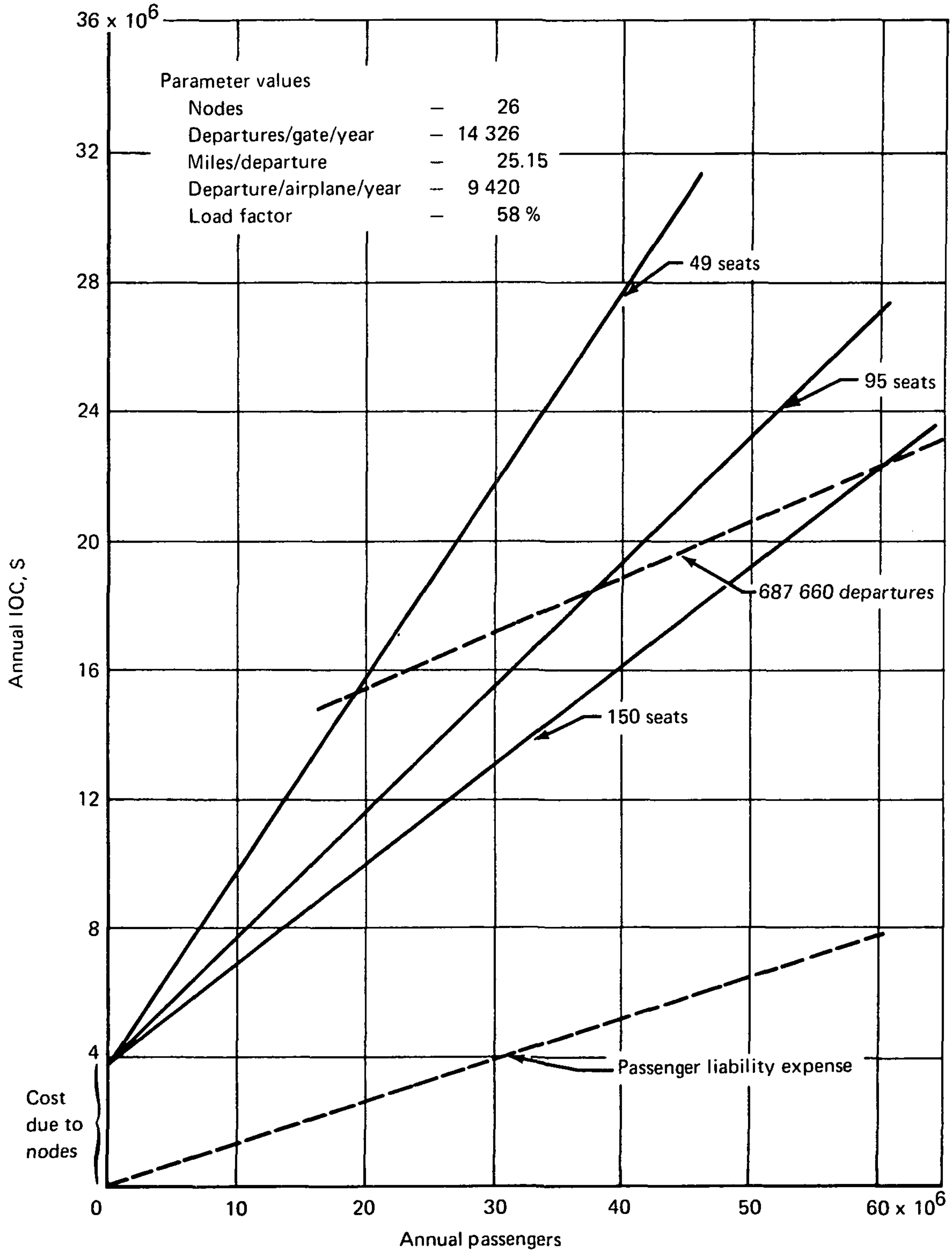


FIGURE 10-32.–IOC TRENDS 58% LOAD FACTOR

11.0 MARKET AND ROUTE ANALYSIS

This section will cover the basic areas of passenger demand potential, network analysis, and the economic evaluation. Its purpose is to show the relationships between system parameters, how these parameters affect the economic evaluative measures, and to select the "best" STOL and VTOL vehicles in conjunction with their concomitant system facilities for the 1975-85 and 1985-95 time periods.

The San Francisco Bay area examined is geographically displayed in figure 11-1. Its boundary is composed of the outermost boundaries of the following nine counties: San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, Sonoma, and Marin. A quote from page 1 of reference 2 helps to characterize this area:

> "In 1965, on these 4.5 million acres, lived 4.4 million people holding 1.7 million jobs. They owned about 2 million automobiles and motorcycles and 285,000 trucks. These operated on 1,400 miles of state highways and 14,300 miles of county roads and city streets."

The reference predicts a 48% increase in person trips from 1965 to 1980, a 78% increase in person trips from 1965 to 1990, and a 70% increase in population from 1965 to 1990. This indicates the requirement for increased capability of the overall transportation media.

In addition to revenue-producing passengers, consideration is given to the transportation of cargo via the intracity air mode during its off-peak periods.

11.1 PASSENGER DEMAND

Given that a person has decided to make a trip, he is confronted with the problem of selecting the travel mode or modes he will use. The elements he will consciously or subconsciously consider include, for each alternative mode, the time it will take for the entire trip (door-to-door), the total trip cost, travel comfort, convenience, safety, pleasure, status, etc. (not necessarily in this order). Further, in considering the purpose of the trip, the environment, his income, the time he must spend away from his job or home, alternate use of his time while en route, and many other items too numerous to mention, the traveler makes the decision based on the collective relative values he assigns to the involved variables. This decision-making process, performed by all travelers, accounts for the mode selection (mode split) from the available alternatives.

If a new mode becomes available, not only will the percent of travelers by each mode shift, but the total number of person-trips may increase. Thus, the passenger demand for the new mode is the sum of those diverted from existing modes and those induced by the new mode by virtue of its availability, novelty, or improvements in one or more variables beyond the threshold limit established by the new traveler.

Another element entering into the already complex task of forecasting passenger demand is the redistribution of traveler residences, places of employment, shopping centers, etc., due to the addition of the air travel mode. To further decrease trip times and costs by the air mode, a traveler might prefer to reside as close as possible to his enplanement point; likewise, he would have a tendency to work, shop, and enact personal business near other air terminals. The resulting distribution of origination and destination points would no doubt induce additional passenger demand that, in turn, would continue to fuel the fire for continued development in and around the air terminals. Since no known method is available for determining how much of the present-day traffic was induced to travel because of one or more changes in the transportation system, it becomes apparent that the problem of forecasting induced traffic is even more formidable.

An analytical approach to predicting mode split, given a perturbation in the total transportation system, is possible only if all of the mode decision-making elements can be expressed quantitatively. Then, relating the quantitative requirements and desires of each traveler to the available mode choices, the decision would be cut and dried. Working collectively with all travelers, the existing modes would provide the data necessary to distribute travelers into discrete classes, providing the inference to accurately predict mode-split changes as a function of variable perturbation.

Because only a few of the trip characteristic elements can be expressed quantitatively, and the available data on intracity air travel is insignificant, the mode-split equation (see sec. 11.1.2.1) developed for this study is based primarily on subjective reasoning. Moreover, the equation predicts passenger demand due to diversion only; for the reasons stated earlier, no attempt was made to predict induced traffic. The air-terminal-pair demand, based only on diversion of existing traffic, is thus conservative.

Since the mode-split equation yields the percent of existing passenger flow that would be diverted if, in fact, the new air mode were introduced, person-trip data are required to obtain numerical demand quantities. The Bay Area Transportation Study Commission (BATSC) (ref. 2) has recently concluded a 5-year study of transportation requirements and ground transportation systems for this area and, in the process, obtained actual person-trip data for 1965. (This organization, now incorporated in the Regional Transportation Planning Commission, has proved most cooperative in providing data and information for this study.) The BATSC study projected these data to provide travel forecasts by mode and other classifications (such as trip purpose) for the years 1980 and 1990. These data, in conjunction with the mode-split equation, provided the passenger demand for each intracity air transportation system examined.

11.1.1 Travel Base Data

The data base for this study is that obtained by the BATSC in connection with its May 1969 report (ref. 2). It was used to construct time-of-day passenger demand distributions and to generate, via the mode-split equation, passenger demand between the air terminals. Data are available for the years of 1965, 1980, and 1990.

11.1.1.1 Passenger Demand Between Air Terminals

To organize data received from many sources and localities on a common basis, a hierarchical or nested system of coding by zonal units was developed by BATSC for the Bay area. The BATSC zonal structure selected for the study herein defines traffic flow geographically in terms of 291 origination and destination analysis zones. Figure 11-2 displays the relative sizes and shapes of the zones, which collectively occupy the entire land space within the study area. This level of detail was considered to be sufficiently small for the traffic and modal-split analysis.

The traffic data used to determine air passenger demand consist of the average number of weekday person-trips occurring in each of the zone-pairs. The 291 zones provide 42 195 zone-pairs for which the number of daily person-trips is recorded on magnetic tape. The Boeing CDC 6600 computer was used to perform the necessary data processing.

Total person-trips for all modes of travel and all purposes of travel was used as the base of traffic. Because the vast majority of total person-trips are via auto, the trip costs and times were computed using auto characteristics (i.e., the relatively small transit traffic is ignored because, in general, the transit passenger is very cost conscious and is not likely to pay the much higher air fare). Furthermore, air demand resulted from diversion of single-occupant auto traffic (40% of auto passengers) only; diversion from multioccupant auto traffic would be insignificant due to the much lower passenger costs.

As part of the network, an air terminal was located at each of the three major civil air carrier airports: San Francisco International, Oakland International, and San Jose Municipal. Thus, the links between these terminals and all the others provide air transportation access to these three major airports.

11.1.1.2 Time of Day (TOD) Demand Distribution

The relationship between the demand rate (e.g., passengers per hour) and the clock time of day is illustrated by a TOD distribution. For example, passenger demand between a residential area and a highly industrialized area would probably be significantly greater in the 6:30 am to 8:30 am and 3:30 pm to 5:30 pm time periods than during the remainder of the day. Although the rate of demand has an effect on access congestion and line-haul frequency, thereby affecting trip time, the resulting incremental change in trip time (door-to-door) is assumed to be nearly equal for all modes. Because trip time in mode split is accounted for by the numerical difference between the air mode trip time and the trip time of the mode from which demand is being diverted, the effect of demand rate will not be visible. The TOD distribution, then, is used only to schedule aircraft in the network model; it is not a factor in mode-split determination of air passenger demand.

The TOD distributions were constructed from BATSC data consisting of departure times (all modes) for individual person-trips within the Bay area. Specifically, departure times (clock time of day) were collated into 15-min incremental time intervals throughout a 24-hr weekday. The resulting distributions are shown and explained further in section 11.4.2.1. Demand densities (passengers per 5-min interval) for each air terminal-pair were computed in the network model by allocating daily demand according to the corresponding time-of-day distribution.

11.1.2 Mode-Split Implementation

The "best" air system is one that satisfactorily minimizes losses or maximizes profit under the somewhat nebulous constraint that it be a worthwhile community endeavor providing widespread service to a significant number of travelers. For the present study, an analytical method of predicting passenger acceptance is required for two important reasons: first, to show the sensitivity of this demand to changes in system variables (e.g., fare, port location, speed, gate time) and, second, to obtain the level of traveler demand for the air mode. These objectives have been met by a simple mode-split equation that reacts to system characteristics in terms of relative changes to trip time and cost.

At the present time, for trip distances exceeding 5 mi, the primary modes of travel in the Bay area include the automobile and public transit (transit includes commuter rail and bus). Diversion of passengers from these existing modes should be based on considerations including the relative characteristics of the highway, transit, and the proposed air systems, characteristics of the trip-maker himself, and the socioeconomic and development aspects of the origination and destination zones. Because significant data are not available to relate ultra-short-haul air travel demand to the above-mentioned considerations, the mode-split technique used herein is one that, in effect, "interpolates" the diverted demand by relating certain characteristics of the highway and transit modes to those of the intracity air mode. Specifically, the differences in trip time and trip cost wholly account for the passenger diversion.

11.1.2.1 Mode-Split Equation

The mode split equation evolved as follows. First of all, because of the reasons already stated (primarily, lack of data and inability to quantify intangible characteristics), it was decided to equate the diversion proportion to ΔC and ΔT:

$$Z = f(\Delta C, \Delta T)$$

where:

Z = decimal fraction of person-trips diverted to air from an existing mode
ΔC = air mode, door-to-door, one-way trip cost minus that for existing mode
ΔT = existing mode, door-to-door, one-way trip time minus that for proposed air mode

Knowing that Z would increase when ΔT increased, but would decrease when ΔC increased, furnished the sign (positive or negative) of the "slope" of Z in relation to changes in the two variables. It is also known that Z will approach 1 when ΔT becomes large and $\Delta C = 0$, and Z will approach zero when ΔC becomes large and $\Delta T = 0$. With these bases, it is apparent that the relationship is a continuous surface that is asymptotic to $Z = 1$ for large ΔT when $\Delta C = 0$, and is asymptotic to $Z = 0$ for large ΔC when $\Delta T = 0$. Additionally, the surface is asymptotic to the plane surfaces of $Z = 0$ and $Z = 1$ for many other coordinate combinations of ΔT and ΔC. A quantitative definition of this three-dimensional surface could be described by one or a series of mathematical equations; however, in view of the

lack of a solid basis, it is folly to be sophisticated. A lot of time and effort is saved by approximating the surface with a plane surface defined by a simple, short, and wieldy equation:

$$Z = Z_O - \left(\frac{Z_O}{\Delta C_O}\right)\Delta C + \left(\frac{1 - Z_O}{\Delta T_O}\right)\Delta T$$

where:

Z_O is the value of Z when $\Delta T = 0$ and $\Delta C = 0$
ΔT_O is the value of ΔT when $Z = 1$ and $\Delta C = 0$
ΔC_O is the value of ΔC when $Z = 0$ and $\Delta T = 0$.

Figure 11-3 shows the linear surface; note that the plane intersects the Z axis at 0.5 and the ΔC axis at ΔC_O. This mode-split surface was used to obtain diversion for positive and negative values of ΔC and ΔT. When Z exceeded 1 or was less than zero, the following rules were applied (approximating the asymptotic conditions):

- When $Z > 1$, set $Z = 1$
- When $Z < 0$, set $Z = 0$

Specific values for Z_O, ΔC_O, and ΔT_O were selected judgmentally to define a "nominal" plane for diverting passengers from an existing mode. The values are $Z_O = 0.5$, $\Delta C_O = \$2$, and $\Delta T_O = 30$ min. Qualitatively, in consideration of a new mode of travel (air, for example) versus an existing mode,

- Where door-to-door trip times and costs are exactly equal, the passengers would be indifferent to the two modes and, therefore, 0.5 (Z_O) would take the new mode.
- Where door-to-door trip times are exactly equal, *nobody* ($Z = 0$) would take the new mode if its cost exceeded the existing mode's cost by \$2 (ΔC_O) or more.
- Where door-to-door trip costs are exactly equal, *everybody* ($Z = 1$) would take the new mode if they saved at least 30 min (ΔT_O) of trip time.

11.1.2.2 Trip Times and Costs

The following equations are used in the computation of one-way trip costs and times incurred by a passenger:

- Single-occupant auto cost
  CA = parking + operating + depreciation + bridge penalty
  = 0.50 + 0.05(DA) + (N-1)500/500 + 0.10(B)

- Air trip cost

  $$CS = \text{access(ride + kiss)} + \text{fare} + \text{transit}$$
  $$= (0.05)(2)(A1) + F + 0.15$$

- Auto trip time

  $$TA = \text{ingress/egress} + \text{avg speed} + \text{bridge penalty}$$
  $$= 5 + (DA/45)60 + 5(B)$$

- Air trip time

  $$TS = \text{auto access} + \text{block time} + \text{airport/wait} + \text{transit egress}$$
  $$= (A1/24)60 + BT + 10 + (A2/15)60$$

where:

DA = auto trip distance (assumed equal to 1.25 times straight-line distance between zone centroids)
N = 1 or 2, the number of autos owned
B = 0 or 1; if a major bridge is involved in trip, B = 1, otherwise B = 0
A1 = ingress distance to air terminal
A2 = egress distance from air terminal
F = air fare
BT = aircraft block time (a function of D)
D = distance between air terminals

Note that auto costs are for the single-occupant driver/owner. Passenger trip cost for multioccupant auto travel would be the total trip cost divided by the number of people in the auto. For any number of people in an auto other than one, passenger trip cost would be at least halved and, thus, diversion of this set of traffic would be negligible. Other modes of travel (transit, walking, etc.) are also insignificant for trip distances exceeding 5 mi (8 km). Therefore, air demand is assumed to come solely from the supply of single-occupant auto travelers.

Line-haul times and fares for the air mode assume nonstop routes. Due to the high density of most air-terminal-pair links, it is estimated that the trip time increase resulting from a multistop route would exceed that resulting in a passenger simply waiting for the next nonstop flight.

Figure 11-4 gives values for ΔC and ΔT as a function of the distance between air terminals (D) for DA = 1.25D, B = 0, and A1 = A2 = 4. The dependent variables ΔC - F and ΔT + BT allow the determination of ΔC and ΔT for any fare and block time.

A salient feature in costing a trip is the inclusion of the cost associated with the ownership of an "extra" car (N = 2) requiring the payment of license fees and insurance premiums, as well as the indirect capital depreciation (decrease of market value with age). Dividing the total of these annual costs ($500) by the number of annual trips (500) for which this extra car is used gives the average fixed cost per trip. An extra car is defined as a car that would not be needed if another acceptable mode of transportation were made available. In other words, by taking the other mode of transportation when applicable, the extra

car would not be used even on weekends, for other purposes, by other family members, etc., because the primary-use car would be available. Although not accounted for in this study, it can be assumed that the present 60% of families who own more than one car will be reduced to a lower percentage by the addition of the air mode.

11.1.2.3 Sensitivity Analyses

The nominal values of 0.5, \$2, and 30 min for Z_O, ΔC_O, and ΔT_O were obtained in a more or less judgmental fashion. The assumptions are: (1) for equal trip times, Z would equal 0 if the air mode trip cost exceeded the auto trip cost by \$2 or more; (2) for equal trip costs, Z would equal 1 if the air trip is at least 30 min faster than by the auto mode; (3) for equal trip costs and times, Z = 0.5. (Of course, in reality, Z would never equal 0 or 1, but would instead very nearly approach these values for ΔC_O and ΔT_O.) Because of the uncertainties, it might be desirable to know how sensitive Z is to small changes in Z_O, ΔC_O, and ΔT_O. The three graphs in figure 11-5 show that Z is quite insensitive to Z_O whereas a greater sensitivity exists for incremental changes in ΔC_O and ΔT_O.

From the mode-split equation,

$$Z = Z_O - \left(\frac{Z_O}{\Delta C_O}\right) \Delta C + \left(\frac{1 - Z_O}{\Delta T_O}\right) \Delta T$$

The following partial derivatives show how Z varies with changes in each of the implicity parameters:

$$\frac{\partial Z}{\partial Z_O} = 1 - \frac{\Delta C}{\Delta C_O} - \frac{\Delta T}{\Delta T_O}$$

$$\frac{\partial Z}{\partial C_O} = \frac{Z_O \, \Delta C}{(\Delta C_O)^2}$$

$$\frac{\partial Z}{\partial \Delta T_O} = \frac{\Delta T(Z_O - 1)}{(\Delta T_O)^2}$$

$$\frac{\partial Z}{\partial \Delta C} = \frac{-Z_O}{\Delta C_O}$$

$$\frac{\partial Z}{\partial \Delta T} = \frac{1 - Z_O}{\Delta T_O}$$

Figure 11-6 shows the proportion of single-occupant auto person-trips diverted as a function of air fare and the distance between air terminals. As listed on the graph, all other variables are held constant. Note that the slopes of the curves are equal to 0.25 per dollar, i.e., the fractional diversion decreases by a 0.25 increment for every dollar increase in fare.

11.1.2.4 Value of Time Concept

Because value of time has become somewhat of a standard in mode-split analysis, it would be interesting to compute the cost of saving time. From the mode-split equation:

$$\Delta C = \Delta C_o - \left(\frac{\Delta C_o}{Z_o}\right) Z + \left(\frac{\Delta C_o}{\Delta T_o}\right)\left(\frac{\Delta T}{Z_o}\right) - \left(\frac{\Delta C_o}{\Delta T_o}\right) \Delta T$$

For $Z_o = 0.50$, $\Delta C_o = \$2$ and $\Delta T_o = 30$ minutes,

$$\Delta C = 2 + 0.067\ \Delta T - 4Z$$

Dividing both sides by ΔT,

$$\frac{\Delta C}{\Delta T} = \frac{2}{\Delta T} + 0.067 - 4\left(\frac{Z}{\Delta T}\right)$$

and, for the augmentor wing STOL, with block time of 5 + 0.16D, A1 = A2 = 4, B = 0, and DA = 1.25D

$$\Delta T = -36 + 1.51D$$

Therefore,

$$\frac{\Delta C}{\Delta T} = \frac{2 - 4Z}{1.51D - 36} + 0.067$$

Figure 11-7 exhibits two graphs: ΔC versus ΔT and $\Delta C/\Delta T$ versus D. The bottom graph can be used to determine the upper and lower limits for the value of time; viz., the cost of saving time ($\Delta C/\Delta T$) for Z = 1 and D > 24 depicts the lower limit for value of time as implied by the mode-split equation, and the $\Delta C/\Delta T$ for Z = 0 and D > 24 is the upper limit for value of time. Note that the upper and lower values of time shift to correspond, respectively, to Z = 1 and 0 for D < 24.

Very interestingly, the median value of time is constant at \$4/hr and occurs when Z = 0.5, i.e., the mode split inherently implies that 0.5 of the travelers value their time at greater than \$4/hr, the other 0.5 at less than \$4/hr.

The asymptote at D = 24 is the point at which $\Delta T = 0$, and, thus, the point at which $\Delta C/\Delta T$ is undefinable; however, $\Delta C/\Delta T$ approaches plus and minus infinity when ΔT approaches zero. At D = 43, everybody (Z = 1) values their time above \$0/hr but nobody (Z = 0) values their time greater than \$8/hr. At D = 30, nobody values their time in excess of \$16.50/hr. It can easily be argued that the ΔC a traveler is willing to pay is dependent on the ΔT for the trip, and not so much on a comparison of the $\Delta C/\Delta T$ ratio to one's value of time.

At D = 24.5, the mode split indicates that the upper limit for value of time is \$124.63/hr; a much lower value would appear to be logical. Yet, because ΔT equals only 1 min, a $\Delta C/\Delta T$ ratio of \$124.63/hr requires that ΔC = \$2.08. Thus, a traveler could easily be misled into continuing to use his automobile if his decision was based on the $\Delta C/\Delta T$ ratio. However, it is quite conceivable that he would take the air mode for a ΔC = \$2.08 even if there were virtually no time savings. This philosophy of considering ΔC and ΔT, rather than $\Delta C/\Delta T$, provides the basis for the mode split in this study.

11.2 MACRO APPROACH

11.2.1 Macro Economic Analysis

11.2.1.1 Model Development

While recognizing that the interaction of traffic, vehicle, network, and system infrastructure is best described and assessed by a simulation process such as the network analysis model (NAM), there is often a need for a formula that can quickly provide reasonable estimates of vehicle/network compatibility. Vehicle parametric analyses have traditionally been based on simple direct operating cost sensitivity without consideration of the impact of system elements (number of nodes and gates, traffic volume, fare elasticity, etc.).

A macro-economic model (MEM) has been developed to provide a ready means of ranking vehicles under various system conditions when the full interactive analysis offered by NAM is not warranted.

11.2.1.2 Method

The equation is developed for an equivalent segment length (determined by inspection of the total network traffic flow, e.g., passenger-miles/passengers) with a base case of traffic, fare, gate requirements, flights per day, fleet size, etc. Variations about the base case thus provide system element sensitivity in addition to the usual vehicle design sensitivities.

Having established the equivalent segment length, vehicle characteristics at this distance are determined and equations for each class of vehicle are developed as in the example below.

Macro Equation.—Taking daily operating profit as a macro measure of economic merit, the economic situation may be expressed as:

$$\text{Operating profit} = \text{operating revenue} - \text{total operating cost}$$

where:

$$\text{Revenue} = (\text{fare})\ (\text{seats})\ (\text{LF})$$

and

$$\text{Total operating cost} = \text{DOC} + \text{IOC}$$

where:

$$\text{DOC} = K^* + (\text{flight operating cost}^*/\text{st mi})(\text{average distance})(\text{flights/year}) + \text{depreciation}^* + \text{insurance}^*$$

where:

$$K = \text{cyclic direct cost (\$/flight)}$$

and

$$\begin{aligned} \text{IOC} = {} & 0.145(\text{nodes}) + 2.7(\text{departures}) + 0.139(\text{gates}) \\ & + 0.00004(\text{seats})(\text{gates}) + 0.0175(\text{miles flown}) \\ & + 0.0034(\text{fleet size}) + 0.04 + 0.125\text{LF}(\text{seats})(\text{departures}) \end{aligned}$$

(Where sensitivity of profit to airplane price is required, starred factors in DOC equation may be expressed in terms of price.)

Incidentally, where traffic sensitivity to frequency, or where fare elasticities are known or postulated, the revenue may be expressed in terms of passengers, fare, and frequency. In such cases, load factors (LF) would vary. In the present example, an arbitrary traffic/frequency relationship is assumed, and fare and loading factor are held constant. Various aircraft sizes are then tested and operating profit comparisons are made.

Example:
- Vehicle class–augmentor STOL airplane
- Equivalent segment length–24 mi
- Base case:
  50 000 daily passengers
  24 nodes
  2000 daily flights
  Fare equation = \$1.75 + 0.064D or \$3.50 (whichever is greater); thus, at 24 mi, base fare = \$3.50

Traffic.–The base daily traffic of 50 000 passengers (parametric or estimated) is assumed to vary at ±10 000 passengers per thousand flights offered. Since the base case rests on 2000 flights for a 50-passenger vehicle, the daily passenger traffic takes the simplified slope/intercept form,

$$\text{Passengers} = 30\,000 + (10)(\text{daily flights})$$

where

$$\text{Daily flights} = \frac{\text{passengers}}{(\text{LF})(\text{seats per aircraft})}$$

so that for an arbitrary load factor of 0.5,

$$\text{passengers} = \frac{30\,000}{1 - \dfrac{20}{\text{seats}}}$$

Fleet Size.—Since only rudimentary scheduling concepts are available in the macro method (in contrast to the time-of-day sensing scheduling capability of the network analysis model), the fleet requirements are determined as follows.

Because of the high peaked commuter demand, it is assumed that the average fleet aircraft will be used for the equivalent of 6 clock hours per typical day. (For annual factors, there are 314 "typical" days in the operating year. This assumes operating at slightly better than half of the weekday schedules on weekends and holidays.) Thus, average flights per day per aircraft can be estimated as

$$\text{Flights per aircraft} = \frac{(6)(6)}{\text{block time + gate time}}$$

where block and gate times are expressed in minutes. Therefore, for an augmentor-wing-type STOL, flying the average trip length of 24 mi (block time 5 + 0.16D and gate time = 3 min)

$$\text{Flights per aircraft} = \frac{360}{5 + 4 + 3} = \frac{360}{12} = 30 \text{ flights/day}$$

Fleet size for the augmentor wing becomes (from the preceding equations)

$$\text{Fleet size} = \frac{\text{30 passengers}}{\text{(load factor)(seats)}}$$

Gate requirements are developed on the basis that since all nodes require at least one gate, and assuming an average day-long gate occupancy of 9 min, (40 departures in 6 hr),

$$\text{Gates} = \frac{\text{nodes or flights}}{40}, \text{ whichever is greater.}$$

On the basis of such postulated factors and relationships, it becomes possible to test aircraft and system elements for comparative economic suitability. An example of such an analysis, based on augmentor wing STOL airplanes, is shown in figures 11-8 and 11-9. The example is limited to sensitivity of operating profit to passenger capacity and load factor, but it is evident from the formula that similar graphic relationships could be developed for fare and airplane price as well as for operational factors such as speed, gate time, time-of-day demand, etc.

Results.—As mentioned above, one of the conventional methods of vehicle economic comparison is to simply compare direct operating costs—usually on an available seat-mile basis. This implies a comparable utilization and load factor for the candidate aircraft. (One frequent outcome of this approach is that the largest vehicle is selected on the basis of lowest unit cost without consideration of the applicability of the assumed load factor and utilization.) In practice, the only valid basis for a general comparison is for a fixed task, with utilization and load factors as a result of the matching of the vehicles to the task. One way in which the task can be specified is to assign a volume of traffic to the equivalent segment length and compare the vehicles on the basis of moving this traffic. An additional refinement is to assign fare and frequency elasticities to the traffic. In the present example, only frequency elasticity has been incorporated.

However, some interesting results are evident:

- According to figure 11-8, operating profits tend to flatten out with aircraft size, even at an assumed load factor (in this case 50%). Furthermore, in the highly peaked, highly directional demand of commuter traffic, it is doubtful if the 50% load factor could be achieved with the large vehicle.

- Indirect and annual direct costs are relatively flat with reducing size (increasing frequency).

- In view of the uncertainty of achieving a 50% load factor in the large vehicle, the effects of load factor were tested as shown in figure 11-9. It is evident that, if operation of the 153-passenger aircraft resulted in a load factor of 40%, it would not be competitive with a similar 100-passenger vehicle matched to the traffic and yielding a 50% load factor. This emphasizes the need to verify that the low unit cost (cents/available seat mile) of the larger aircraft can be effectively used. This verification is more feasible in the network analysis model (NAM) described in the following section.

While the macro approach is a step forward from the traditional cost comparison, a simulation process, such as is used in the NAM, provides a far greater degree of operational rationality in the economic outcome.

In the following section, the macro method is used to gain insight into the consequences of off-peak utilization.

11.2.2 Off-Peak Utilization

11.2.2.1 Introduction

In view of the extreme traffic peaks normally associated with metropolitan transportation, and resulting low average utilization of system elements, it is logical to consider off-peak utilization opportunities for economic relief.

In the case of the metropolitan air transport (MAT) system, many of the aircraft will be on a standby basis from about 10 am to 4 pm and from 7 pm until 7 am. Investigation of revenue opportunities for these time intervals include:

- Cargo } intrametropolitan and intercity
- Mail }

- Intercity passenger service

However, it should be pointed out that utilization for utilization's sake is not necessarily a worthwhile objective. Additional utilization must produce operating revenue that is at least above the associated total cost. That is, it must cover all costs that are not written off against regular operations.

11.2.2.2 Cost Comparison

The first step is to examine the typical MAT aircraft in economic terms relative to its most likely intracity and intercity competitor, in this case, the truck. The results are as shown in table 11-1 where it can be seen that, even without adding the cost of the additional unload-load cycle required by the air transport, the truck has unit-cost superiority. Thus, it seems evident that the air system must rest on "system" advantages. (As is well known, present-day air cargo markets depend on such system advantages as lower inventory, warehousing, and pilferage costs to compete with lower-cost surface modes.)

Even a preliminary examination of the system benefit possibilities in the proposed MAT network indicates that an in-depth analysis would be required for this aspect alone. For example, to meet the urgent requirement to minimize gate time during peak passenger operations, the aircraft are configured for rapid enplaning and deplaning of passengers. It is estimated that a quick-conversion configuration would add 8% to the direct cost of the aircraft.

11.2.2.3 Subsidy

The general economics estimated for the MAT system seem certain to require at least an initial investment grant if not an operating subsidy as well. In this case, an important question arises: Can a publicly funded transport system compete with private organizations such as trucking companies? (It may be contended that the truckers are using public-funded roads in pursuit of their business, but at least the trucks are taxed for highway use.) This introduces the question of how the system element costs should be allocated in determining off-peak customer charges and resulting MAT profit.

As table 11-1 shows, the air vehicle would prove extremely costly at intrametropolitan distances compared with trucks, and a substantial value of time is thus required for airborne commodities. In addition, the truck can usually provide door-to-door service whereas terminal delays, at least during commuter peaks, must be added to the air trip.

11.2.2.4 Revenue Requirements

Another method of examining the economic feasibility of off-peak utilization can be developed by means of the macro economic model described earlier in this section.

From figure 11-9 it is seen that, if the large (153-seat) augmentor wing STOL is operated at an average load factor of 25%, for example, an operating loss of $20 000 daily will be incurred. (No allowance for possible nonoperating system—facilities, land, etc.—investment expense.) If the direct costs are increased to account for cargo conversion, the loss will increase to about $28 000. If about half of the 30 fleet aircraft are available for off-peak uses at any one time, this loss will be about $2000/day per off-peak aircraft.

Figure 11-10 shows the relationship between revenue levels and operating radius for the 15 available aircraft at a 50% cargo load factor. The range of truck rates with which the MAT system would have to compete is shown cross hatched. While the MAT cargo aircraft could fly additional flights, figure 11-11 shows that, at the productivity levels to achieve the

lowest revenue rate, even the half-fleet capacity exceeds by a wide margin the 1968 total originating air cargo levels for the Bay area. When it is considered that much of this cargo volume originates within a few-mile radius of the CTOL airports, at distances where the air system cannot be competitive, the capacity imbalance is even more dramatic.

11.2.2.5 Intercity Passenger Service

The MAT system, at first glance, seems to have considerable intercity passenger potential in service to peripheral centers at the fare levels possible with several of the study aircraft. However, figure 11-10 can be used to approximate fare requirements required to recover metropolitan system losses.

Consider Sacramento, the state capital, located 78 smi from San francisco. At 30 flights per day (two trips per airplane) the ton-mile cost is $1.70 or 17 cents per mile per passenger or a one-way fare of $13.25 (not including indirect costs), which exceeds present intrastate air fares. (Using this size of airplane, the 30 flights per day frequency would offer about 60% more seats than presently in service between these points. However, "close-in" service would undoubtedly improve air traffic to some extent.)

Furthermore, it is generally conceded that short-haul passenger acceptance is sensitive to frequency matching of time-of-day demand, and such matching would be very limited if based on off-peak availability of the MAT aircraft. However, system losses could be partially reduced by carefully selected intercity passenger service.

11.2.2.6 Mail

Although it has been shown that the MAT aircraft cannot compete with trucks on a straight cost comparison, there is some hope of U.S. Post Office support for the following reasons:

- The mail rate at which helicopter operators were paid for intracity transport is at a level that would offset out-of-pocket operating cost of some of the study aircraft (see for example fig. 11-10).

- With current interest in improving the postal system, the speed advantage offered by the MAT aircraft at intrametropolitan distances could stimulate postal support.

- Integration of regional postal centers with MAT airports could effect the kind of system benefits that are needed to justify the higher unit costs of air transport. (However, it is beyond the scope of the present study to carry out the in-depth analysis required to verify system benefits.)

11.2.2.7 Conclusions

- If intrametropolitan air transport is subsidized, competition with other commercial cargo transport systems would probably be constrained except for public service such as mail.

- In any case, the side-by-side comparison of MAT aircraft and truck transport of cargo indicates truck unit costs are lower, at least to the limits of the metropolitan region, even without consideration of the costs of the additional loading/unloading cycle required by air transport. However, mail loads, if compatible with MAT aircraft size, look feasible for loss amelioration.

- When operating losses of the MAT system are written off by off-peak use of cargo conversion aircraft, the required rates exceed those of trucks, even when the required cargo volume exceeds that of all air cargo (freight, express, and mail) originating in the Bay area in 1968.

- Intercity passenger service could be offered at fares that would defray intra-metropolitan losses, but schedules would be restricted by the vehicle demand created by commuter peaks.

- Complete analysis of system benefits would require a separate study permitting careful examination of current competitive systems, projected surface competitive development, and special transport opportunities possible in high-value goods, time-critical commodities, intercity scheduling requirements, etc.

11.2.2.8 Recommendation

To fully develop current understanding of the economic limits of short-haul air transport, an analysis of metropolitan interactive systems (mail and cargo levels and surface transport development) should be carried out in depth. The recommended study should not be encumbered by air transport technology projections but should rest on pre-established vehicle and supporting system assumptions.

11.3 FARE FORMULATION

Assuming that the air fares will not be regulated in the proposed intracity network, the idea of being able to formulate a fare equation to accomplish some end (maximize profit or social benefit for example) is intriguing. The importance of fare has already been displayed in figure 11-6, wherein, for a given set of typical conditions, it was found that fractional diversion decreased by an increment of 0.25 for every dollar increase in fare. The first step in determining fare is to specifically define the problem, i.e., given that fare is completely unrestrained, what objective function should it satisfy (or optimize)? Qualitative goals, such as "improve transportation for as many people as possible," will not be dealt with because they could not be expressed in mathematical form. Listed below are two quantitative objectives that might be achieved:

- Maximize system profit

- Satisfy a given fractional diversion versus range relationship

The logic behind an attempt to establish a fare that maximizes profit is clear. On the other hand, a fare predicated on the diversion of a precise proportion of travelers to the novel air mode needs a bit of explanation. To obtain or strengthen governmental cooperation and support, promoters might want to show that the intracity air concept is not only useful as a transport system per se, but that it would serve, by virtue of its fare, to ecologically improve the local environment.

For example, to take an extreme case, a fare that decreases as trip distance increases would certainly tend to divert a greater fraction of the longer range trips to air travel. The incentive provided could increase demand for residential and industrial construction in the fringe areas surrounding the megalopolis. This, in turn, would supply more passengers for long-distance routes. Other long-term effects are easily recognizable.

As another example, suppose it is decided that the diversion fraction should be constant and independent of air trip distance. A fare equation to accomplish this, or any other relationship between fractional diversion and range, could be desirable.

Additional bases for fare might include simplicity (e.g., constant fare), cost (operating, direct, total, or other), cost of major competing mode, distance of outermost node from city center, etc.

11.3.1 General Equation

From the mode-split formula (sec. 11.1.2.1),

$$\frac{\Delta C}{\Delta C_o} - \frac{\Delta T}{\left(\dfrac{\Delta T_o Z_o}{1 - Z_o}\right)} + \frac{Z}{Z_o} = 1$$

where:

Z = fractional diversion
ΔT = auto trip time - air trip time = TA - TS
ΔC = air trip cost - auto trip cost = CS - CA
trip = one-way, door-to-door
ΔC_o, ΔT_o, Z_o = mode-split constants (see fig. 11-3)
CS and CA = passenger-incurred costs

ΔC can also be expressed as

$$\Delta C = CS - CA = CSNOF + F - CA$$

where:

CSNOF = air trip cost - fare = CS - F,

then, the equation for fare F is:

$$F = \Delta C + CA - CSNOF$$

$$F = \Delta C_o \left[1 - \frac{Z}{Z_o} + \frac{\Delta T}{(\Delta T_o) Z_o} - \frac{\Delta T}{\Delta T_o} \right] + CA - CSNOF$$

11.3.2 Fractional Diversion Objective

It is seen that F is a function of Z and trip time and cost elements, where time and cost are expressed as functions of distance (see sec. 11.1.2.2). As an example, to illustrate the macro approach, suppose it is desired to find a fare that will divert single-occupant auto passengers to the air mode according to the following relationship:

$$Z = 0 \text{ for } D < 10$$
$$Z = -0.2 + 0.02D \text{ for } 10 \leqslant D \leqslant 60$$
$$Z = 1 \text{ for } D > 60$$

where D is the distance between air terminals in statute miles. Let the passenger diversion apply to single-occupant auto drivers whose auto trip distance DA = 1.25D, and, if he were to take the air mode instead, lived 4 mi (6.3 km) (A1) from the closest air terminal and would have to travel 4 mi (6.3 km) more (A2) after landing at the destination air terminal. Assume also that B = 0 (no bridge) and N = 2 (two autos owned). Remembering that Z_o = 0.5, ΔC_o = \$2, and ΔT_o = 30 min, the required fare for an aircraft having a block time of 5 + 0.16D min (augmentor wing STOL) would be:

$$F = 0.55 - 4Z + 0.163D.$$

For the Z relationships given above,

$$F \geqslant 0.55 + 0.163D \text{ for } D < 10$$
$$F = 1.35 + 0.083D \text{ for } 10 \leqslant D \leqslant 60$$
$$F \leqslant -3.45 + 0.163D \text{ for } D > 60$$

The inequality symbols merely imply the existence of fare limits corresponding to the upper and lower limits of 1 and 0 for Z. Hence, because a fare equal to 0.55 + 0.163D would result in zero STOL passengers (Z = 0) for D < 10, a greater fare would obviously be a higher deterrent. Likewise, a fare less than one that diverts all (Z = 1) of the qualifying auto drivers (qualifying refers to those auto trips characterized by A1 = A2 = 4 mi (6.3 km), B = 0, N = 2, DA = 1.25D) to the STOL mode would also push Z to 1. Of course, in the latter case, F should be held at its upper limit to increase profit.

The above fare equation, satisfying a fractional diversion versus range relationship, is shown graphically in figure 11-12.

The purpose of presenting this example is to aid in the explanation of the limitations inherent in the macro approach to fare formulation. Obviously, fare cannot vary from person to person, depending upon where he begins and ends his trip relative to the most

appropriate air terminals or upon his individual trip cost and time by auto relative to the alternative air mode. The point being made is that fare must be tailored (holding all other variables, restraints, criteria, objectives, etc., constant) to the so-called "average" potential passenger, where average refers only to ingress, egress and line-haul variables versus the more direct trip by auto. Final results herein are based on values for ingress and egress distances of 4 mi (6.3 km) each, and auto trip distances of 1.25D. These values are assumed to be close to weighted averages; computations cannot be made because distributions of travel distances between precise origin and destination (O/D) points are not known (for each trip, the BATSC data tapes give only the centroids of the O/D zones rather than the actual O/D points). The resulting fare equation, based on average trip distances, satisfies the objective function only in regard to that particular set of travelers who, in fact, would have to travel ingress and egress distances of 4 mi (6.3 km) each and, in the auto mode, would have a trip distance of 1.25D, B = 0, and N = 2. However, parametric sensitivity studies (see fig. 11-16) indicate that a nominal fare so determined would be about as good a starting point as one could hope to get; further refinement could be achieved via trail and error network model simulations that would zero-in on a more accurate fare equation satisfying the objective function for the entire collective array of travelers. (Actually, the network model could be used solely, but the expense of the many more trial and error runs would far exceed that for the macro approach.)

Another possible approach to finding a fare equation that satisfies a given $Z = F(D)$ function is shown in figure 11-13. The top graph shows fractional diversion versus range D for four different fare equations; the data points were obtained from the mode-split routine of the network model, thus, the actual values of B, N, A1, A2, and DA were used instead of those assumed in the macro approach. The information contained in these curves was caused to plot the four fare curves for constant Z of 0.1, 0.2, 0.3, and 0.4 in the bottom graph. Now, by interpolation, the bottom family of curves can be used to determine fare equations for any Z versus D relationship.

To compare this approach with the macro approach, the fare for $Z = -0.2 + 0.02D$ is plotted. Note that, because data were not available to plot fares for constant Z between 0.5 and 1, the resulting fare equation of $F = 1.50 + 0.05D$ is valid for only $13 \leqslant D \leqslant 30$ $(0.1 \leqslant Z \leqslant 0.4)$. Note also that the two approaches yield different fare equations (for $Z = -0.2 + 0.02D$, F(model) = \$1.50 + 0.05D, and F(macro) = \$1.35 + 0.083D). The difference is due to errors in selecting 4 mi (6.3 km) and 1.25D, 0, and 2 as constant averages for A1, A2, DA, B, and N, and due to the fact that the curves in the top graph do not fit the data points very closely. It is satisfying, however, to observe that the fare equations generated in figure 11-13 for Z = 0.1, 0.2, 0.3, and 0.4 are identical to those computed on a macro basis.

Setting aside the inability of the data points to lie on smooth curves, the method of figure 11-13 would be preferable for $Z = F(D)$ objective functions if additional data (more network model runs) were obtained to complete the family of curves in the bottom graph (Z = 0, 0.1, . . . 1). Note that this methodology is applicable only to the solution of $Z = F(D)$ objective functions; fares for other objective functions are determined differently on a macro scale (average values for A1, A2, and DA).

Regardless of the relationship of Z to D, Z can never exceed 1 or be less than 0. The two straight dashed lines in figure 11-12 are the maximum and minimum fare limits for STOL corresponding to constant Z values of 0 and 1. The diversion ability of a fare versus D equation can readily be determined by plotting the relationship directly on figure 11-12 and determining the values for Z by linear interpolation.

Using the cost and time equations presented in the mode-split description and setting $Z_0 = 0.5$, $\Delta C_0 = \$2$, $\Delta T_0 = 30$ min, DA = 1.25D, B = 0, N = 2, and A1 = A2 = 4 mi (6.3 km), the equation for fare reduces to:

$$F = 0.88 - BT/15 - 4Z + 0.173D$$

where BT = block time in minutes. Note that block time is the only aircraft characteristic accounted for in the fare equation. Therefore, as examples for the STOL aircraft (BT = 5 + 0.16D),

$$\begin{aligned}
&F \geqslant 0.55 + 0.163D \text{ for } Z = 0\\
&F = 0.15 + 0.163D \text{ for } Z = 0.1\\
&F \leqslant -3.45 + 0.163D \text{ for } Z = 1\\
&F = 1.35 + 0.083D \quad Z = -0.2 + 0.02D \text{ for } 10 \leqslant D \leqslant 60
\end{aligned}$$

Note that when Z = F(D), negative Z is set equal to 0, and Z exceeding 1 is set equal to 1. A negative fare means the operator would have to pay travelers to take the air mode to achieve the objective Z function.

11.3.3 Maximum Profit Objective

A second objective function would be total system operating profit P.

$$P = \text{revenue} - \text{TOC}$$

Let G = number of single-occupant auto travelers, then

$$\text{Revenue} = (Z)(G)(F)$$

For the 49-seat augmentor wing STOL (1975) with an average LF = 0.5, network model output values for utilization of 40 flights/day, and an average IOC of \$1.14 per passenger,

$$\text{TOC per passenger} = \frac{46 + 0.4D + \dfrac{409 + 90}{40}}{(0.5)(49)} + 1.14$$

$$= 3.50 + 0.016D$$

Therefore,

$$\text{TOC} = (\text{TOC per passenger})(Z)(G)$$
$$P = (Z)(G)(F) - (3.50 + 0.016D)(Z)(G)$$

but

$$F = 0.55 - 4Z + 0.163D$$

Therefore,

$$P = G[-4Z^2 - 2.95Z + 0.147DZ]$$

Setting the partial derivative of P with respect to Z equal to zero, and then explicitly solving for Z gives

$$\frac{\partial P}{\partial Z} = -8Z - 2.95 + 0.147D = 0$$

$$Z = 0.0184D - 0.369$$

Because Z must fall within the limits of 0 and 1,

$$Z = 0 \text{ for } D < 20$$
$$Z = 0.0184D - 0.369 \text{ for } 20 \leqslant D \leqslant 74$$
$$Z = 1 \text{ for } D > 74$$

This Z function is that which must occur to obtain a maximum profit ($\partial P/\partial Z = 0$). The necessary fare is (49-seat augmentor wing STOL):

$$F \geqslant 0.55 + 0.163D \text{ for } D < 20$$
$$F = 2.03 + 0.089D \text{ for } 20 \leqslant D \leqslant 74$$
$$F \leqslant -3.45 + 0.163D \text{ for } D > 74$$

The resulting profit per passenger is:

$$P/(G)(Z) = -4Z - 2.95 + 0.147D$$
$$= -1.47 + 0.073D \qquad \text{for} \qquad Z = 0.0184D - 0.369$$

The maximum profit fare is plotted in figure 11-12.

11.3.4 Additional Results and Sensitivities

Other STOL fare equations that might be of interest are:

- Fare that maximizes total revenue:

$$\text{Max rev} = [(Z)(G)(F)]_{max} \propto [(Z)(F)]_{max}$$
$$(Z)(F) = -4Z^2 + 0.55Z + 0.163DZ$$

$$\frac{\partial[(Z)(F)]}{\partial Z} = -8Z + 0.55 + 0.163D = 0$$

$$Z = 0.069 + 0.02D \text{ for } 0 \leqslant Z \leqslant 1$$
$$F = 0.27 + 0.083D \text{ for } 0 \leqslant D \leqslant 47$$

- Break-even fare, where revenues = operating costs (49-seat augmentor, load factor = 0.5 and utilization = 40 flights per day):

$$\text{Profit} = G(-4Z^2 - 2.95Z + 0.147DZ) = 0$$
$$Z = -0.737 + 0.037D \text{ for } 0 \leqslant Z \leqslant 1$$
$$F = 3.50 + 0.016D \text{ for } 20 \leqslant D \leqslant 47$$

(Remember that for $0 > Z > 1$, the fare equation becomes the dashed lines in figure 11-12.)

Figure 11-14 shows the fares for Z = 0 and Z = 1 for the 1975 helicopter. Figure 11-15 displays the same curves for the 1985 tilt-rotor VTOL. As discussed previously, figure 11-12 is applicable to both the 1975 and 1985 augmentor wing STOL (all seat capacities).

11.4 NETWORK ANALYSIS

This section is concerned with detailed analyses of the intraurban system. All the aircraft designed for the study are tested in the operating environment forseen for 1980 and 1990. The method of analysis is to first run a computerized demand model to get 1980 and 1990 demands for all segments, and then to run each aircraft, in turn, through the network model using the demands created previously. The network model computes fleet size and all operating characteristics of the system. This allows one to compare the various aircraft types and sizes.

The action of the network model is described in section 11.4.1. The base cases are defined in detail in section 11.4.2. The results of the base-case analysis are presented in section 11.4.3. Section 11.4.4 discusses the effects of modifying some of the base-case parameters.

11.4.1 Description of Network Model

The function of the network model is to determine the economic and operating characteristics of a particular vehicle in a specified operating environment. The model performs this function by constructing a realistic schedule for the aircraft. Once a complete schedule is available, all aspects of system operations can be determined (e.g., gate requirements, operating profit, service level are directly calculated once a schedule has been determined). Thus, the major task of the network model is construction of a schedule.

Before a schedule can be produced, the available demand must be known. Unfortunately, the demand depends, partially, upon service level. The latter isn't known until after the schedule is complete. For this reason, a demand model (mode split) must be included in the network model. For this study, the demand model was separate from the scheduling model. In the base cases analyzed, the service level assumed in the demand model was realized in the schedule so that no second pass was needed.

The demand model used in the study is discussed in section 11.1. The rest of this section (11.4.1) will be concerned with the scheduling and evaluation portions of the network model.

Following is a list of the inputs required by the network model:

- Airplane characteristics
  - Block speed
  - Seats
  - DOC
  - Daily depreciation
  - Daily hull insurance

- System characteristics
  - List of nodes with gate time at each
  - List of segments with distance for each
  - Morning and evening curfews
  - Target load factor
  - Partial schedule (if desired)
  - IOC
  - Fare
  - Percent of demand that must be satisfied

- Traffic
  - Daily passenger flow by segment
  - Demand distribution by time of day for each link
  - Passenger tolerance time (maximum length of time a passenger will deviate from his desired departure time)

- Miscellaneous inputs
  - Length of simulation interval—the smallest time interval considered by the model.

The first step of the model is to break the day into pieces one simulation interval wide (for this study the simulation interval was 5 min). The demand for each link in each interval (5-min period) is calculated by integrating the time-of-day demand curves between the limits of the interval.

The total demand at any time can now be calculated by summing the appropriate interval demands. For instance, if the passenger tolerance time is 10 min, the total demand for an 0900 departure would be the sum of the demands in the intervals: 0850-0855, 0855-0900, 0900-0905, 0905-0910. Having constructed the interval demands, the program is ready to begin scheduling. There are two major steps involved in the scheduling process. Step 1 involves searching all links for a possible flight, step 2 involves searching only those links originating where the airplane is currently stationed. The steps are described below.

- Step 1—All the demand tables are searched. Total demands are calculated for each flight time. The earliest flight meeting the target load factor is flown and the demand tables are adjusted accordingly. If no flight meets the criterion, the schedule is complete.

- Step 2—All the demand tables for segments emanating from the city at which the airplane is currently located (i.e., the destination of the last flight) are searched. Total flight demands are calculated. Two cases are possible.

  - Case 1: There is a flight within 1 hr that meets the target load factor. In this case, the earliest such flight is flown, the demand tables are adjusted, the target load factor is reset to its input value, the arrival time in the next city is determined, and step 2 is repeated for the new city.

  - Case 2: No satisfactory flights exist within 1 hr. There are two subcases.

    . Subcase A. It is late enough to overnight the airplane. In this case, allow the airplane to overnight at this city and repeat step 2 starting at the a.m. curfew.

    . Subcase B. It is too early to overnight the plane. In this case, the target load is cut in half and step 2 is repeated. This is done four times, if necessary. If no acceptable flight is found after four tries, the airplane must be ferried. To find out where to ferry the plane, execute step 1 to find the next revenue flight, then ferry the plane to the origin of that flight.

When the program jumps out of the step-1/step-2 loop, a schedule has been produced. It may, however, contain aircraft that are grossly under utilized. For this reason, the model discards any plane that carries fewer than four full plane loads of passengers per day. The remaining aircraft constitute the fleet. If a sufficiently high percentage of the total available demand has been carried, the program proceeds to the economic evaluation section. Otherwise, the basic target load factor is reduced, demand tables are re-established, and a new schedule is produced.

The economic evaluation consists of calculating DOC, IOC, revenue, and profit per day. Because of the schedule, the costs can be correctly calculated. For example, no utilization curve need be assumed for DOC, and IOC can be based upon causal factors. The economic calculations are done for each airplane, for each segment, and for the total system.

The number of gates needed at each STOLport (a big contributor to IOC) is calculated by finding the maximum number of departures in a 1-hr period, dividing this number by 10 and adding one gate. This calculation assumes 10 planes per hour can be processed through a gate. The figure is conservative compared to the 3-min gate time used in all model runs.

11.4.2 Base-Case Description

To adequately compare various aircraft types and sizes, and to evaluate the benefits of an intraurban air transportation system, a basic set of values was determined for the network model inputs. The base-case values represent best estimates of what would occur were an air system implemented. However, even as this report is being written more is being learned about ultra-short-haul air systems and their best estimates are not entirely firm. For example, the latest computer results tend to indicate that a fare lower than the base fare would produce more demand and would reduce the operating loss. Section 11.4.4 on parametrics discusses effects of varying the base-case inputs.

Four different air transportation systems have been evaluated in this study: VTOL and STOL systems in 1980 and 1990. The traffic input is different for each of these cases because the locations of the V/STOLports are different, the block speed of the VTOL and STOL vehicles are different, and because of the growth in total travel demand between 1980 and 1990. With the exception of the traffic, port locations, and aircraft data, the cases have identical inputs.

The simulation interval used in all network model runs was 5 min. The other inputs that define the base cases are: traffic inputs (described in section 11.4.2.1) and system inputs (described in section 11.4.2.3). Section 11.4.2.2 lists the characteristics of all the aircraft evaluated.

11.4.2.1 Traffic Data and Time-of-Day Demand Distributions

Demands between all STOLport pairs and VTOLport pairs were computed by running the demand (mode split) model on the 1980 and 1990 BATSC person-trip tables for the 291 zones in the study region (see sec. 11.1). The trip tables give, for the year in question, the total travel demand between all 42 195 zone pairs. The demand model assumes all people in a zone to be concentrated at the centroid of that zone. The nearest V/STOLport to each zone centroid carries any air traffic to or from that zone. For each zone pair, the model calculates the nearest V/STOLports and applies the mode split equation (see sec. 11.1.2) to the total travel demand between the zone pair. The traffic diverted to the air mode is added to whatever traffic has already been diverted to the pair of nearest V/STOLports. When all zone pairs have been examined, the traffic for all V/STOLports has been determined.

The values of the parameters of the mode-split model used in the base case are shown in section 11.1.2.2. Of particular interest is the 10 minutes allowed for waiting time for the air mode. This time is really the interval within which a passenger will deviate from his desired departure time. We assume that the average passenger is willing to deviate by ±10 minutes. The fare level used in the mode split model was 1.75 + 0.064 (distance), with a minimum fare of $3.50.

The results of the demand model are presented in tables 11-2 through 11-6. For each of the 5 cases, four demand matrices are presented. The first shows the number of trips produced by a V/STOLport area and attracted to each other V/STOLport area. The second shows production-attraction demand for all modes (i.e., total daily traffic). The third matrix shows total two-way demand on each segment (e.g., the entry for port 1 to port 5 is the sum of the 1 to 5 and 5 to 1 entries in matrix 2). The fourth matrix is like the third but shows V/STOL demand instead of total demand.

The fourth matrix is the input to the network model. The whole 30-by-30 matrix of demands is far too large to schedule. It would not fit in the model and would require far too much time to schedule if it could be forced to fit. Instead of using the entire matrix, only zone pairs for which one-way demand exceeded 250 passengers per day were considered. With the most peaked time-of-day demand distribution used, 250 passengers per day yields about three flights in the peak period with over 30 passengers each. For the rest of the day, the maximum demand is 13 passengers (assuming a 30-min passenger tolerance time). With the less peaked curve, demand never gets above 24 passengers and runs under 10 except in the peaks. Thus, a market of 250 passengers per day is quite marginal, and smaller markets can reasonably be excluded.

Table 11-7 shows the segments that were accepted for the 1980 STOL and VTOL systems, along with the demand and segment length. Table 11-8 gives the same information for the three 1990 systems: STOL, helicopter, and tilt-rotor. The tilt-rotor and helicopter systems differ because the increased block speed of the tilt-rotor produces more demand.

The time-of-day demand distributions used in the base case are shown in figure 11-16. Curve 1 is used for all V/STOLport pairs that do not include port 1. Curve 2 is used from port 1 to all other V/STOLports. Curve 3 is used from all ports to port 1.

These curves were selected because they represent the 900 curves derived for each V/STOLport pair. These 900 curves were produced from a BATSC data tape giving detailed information about over 100 000 trips gathered during a survey of 30 000 households.

For each trip, the zones of departure and arrival and time of departure are given (in addition to much other information) as well as a scale factor showing how many trips this one trip represents in a full 1965 system. The nearest V/STOLport was determined for each zone, and the total number of people traveling between each V/STOLport pair in 15-min time intervals was accumulated.

The most striking characteristics of the resulting set of curves was the sparseness of the data. Most segments had so few people that no reasonable curve could be drawn. Because of this, it was necessary to draw "typical" curves. Another striking characteristic of the curves

was the big difference between segments containing port 1 and those not including port 1. Almost all segments in the latter category showed two peaked curves without severe peaking. The segments linked to port 1 all showed severe morning or evening peaking, depending upon whether they were to or from port 1. Figures 11-17, 11-18, and 11-19 show examples of each of the three curves with the "typical" curves superimposed. For some segments, of course, the "typical"curves don't fit the specific curve as well. In general, however, the curves chosen as inputs to the network model fit the available scanty data quite well.

The passenger tolerance time used in the base case was 30 min. This means that anyone unable to find a flight within ±30 min of his desired departure time does not take the air mode. The average time a passenger had to deviate from his desired departure time varies from case to case, but it is always close to 14 min. Although this is greater than the 10 min assumed in the mode-split model, it is believed that the two times are consistent. The average deviation from desired departure is considerably less than 14 min in the peak periods and more during the valleys of the time-of-day demand curves. Thus, those people who are most time sensitive, those commuting to work, have service, better than that assumed in the mode-split model; other people who are not as time sensitive get slightly worse service. Overall, the 14-min average wait fits nicely with the 10 min assumed in mode split.

11.4.2.2 Airplane Data

Table 11-9 lists the characteristics of all 1975 aircraft considered by the network model. Table 11-10 gives the same information for the 1985 aircraft. These tables do not completely describe the aircraft; they contain only the information that goes into the network model.

11.4.2.3 System Data

All systems considered have common inputs except for their nodes and segments. The common inputs are the following:

- Morning curfew—0600 hr
- Evening curfew—2200 hr
- Target load factor—0.5
- Gate time—3 min
- Fare—\$1.75 + 0.064 (range in st mi) with \$3.50 minimum
- IOC = 0.14458(nodes) + 1.717(departures)
  + 0.138723(gates) + 0.0151(miles flown)
  + 0.00004052(seats)(gates) + 0.003443(fleet)
  + 0.0233(departures)(seats)
  + 0.125(departures)(seats) + 0.125(departures)(seats)
  (LF) + 0.0000792(seats)(miles flown)

where:

IOC = indirect operating cost in millions of dollars per year
Nodes = number of terminals in system
Departures = number of departures per year in millions
Gates = total gates in system
Seats = airplane capacity
Miles flown = total statute miles flown per year in millions
Fleet size = number of planes
LF = average load factor

No partial schedules were used and there was no specified percentage of the total demand that had to be satisfied.

The 1975 STOL system consists of 24 STOLports with 130 one-way segments linking them. The 1975 VTOL system has 26 VTOLports with 148 segments. The 1990 STOL system consists of 26 STOLports and 186 segments. The 1990 helicopter and tilt-rotor systems both have 26 VTOLports; the helicopter system has 222 segments, the tilt-rotor has 240. The VTOLports and STOLports have slightly different locations. In general, the sites of VTOLports and STOLports having the same number are very close, if not identical. Exceptions to this are VTOLports 17, 18, and 19. VTOLport 17 is at the MacArthur BARTD station. No STOLport is comparably situated. VTOLport 18 is equivalent to STOLport 17, VTOLport 19 is equivalent to STOLport 18. No VTOLport corresponds to STOLport 19. Section 8.3 discusses the terminal locations in more detail.

11.4.3 Base-Case Results

The results shown in this section form the basis for the economic comparison of aircraft types and sizes. For this comparison to be meaningful, the competing aircraft should carry the same percentage of the available demand. This is so because the first aircraft scheduled are the most profitable since they have the entire demand available to them. As the remaining demand decreases, the airplanes being scheduled become less profitable. Thus, if one aircraft type carries 86% of the demand and loses \$15 000 per day and another carries 80% and loses \$10 000 per day, it is very likely that the first type is the better airplane. The first type could likely carry 80% of the demand and lose less than \$10 000. In any event, the two should be compared at 80%.

Of course, if the aircraft carrying the smaller percentage of available demand sustains a larger operating loss, it is clearly the inferior of the two aircraft being compared. This occurs in most of the base-case runs. Thus, in the economic analysis of the base cases, it was not necessary to compare the aircraft at precisely the same percent of demand carried. For some of the sensitivities discussed in section 11.4.4, it was necessary to use the more accurate mode of comparison.

Section 11.4.3.1 contains a summary of network model output for each aircraft in each time period. Section 11.4.3.2 contains a detailed discussion of the base case—the 49-seat augmentor wing STOL in the 1980 time period.

11.4.3.1 Summary of Network Model Output

The network model results used in the economic analysis of section 11.5 are presented in this section. For each aircraft run through the network model, a summary of the airplane activity and a set of economic and operating statistics are given. For the most part, the output is self-explanatory. In the flight statistics output (tables 11-11 through 11-25), FLT NBR means tail number, HRS UTIL means daily utilization in hours, PAX means daily passengers carried, WGT L.F. means distance-weighted load factor, CUM PRO means cumulative profit, and C PCNT means cumulative percent of total demand carried. All costs and revenues are in dollars per day.

The results are presented in the following order:

- 1980 demand

	Table
49-seat 1975 augmentor wing STOL	11-11
95-seat 1975 augmentor wing STOL	11-12
153-seat 1975 augmentor wing STOL	11-13
50-seat 1975 helicopter	11-14
98-seat 1975 helicopter	11-15
150-seat 1975 helicopter	11-16

- 1990 demand

	Table
49-seat 1985 augmentor wing STOL	11-17
95-seat 1985 augmentor wing STOL	11-18
153-seat 1985 augmentor wing STOL	11-19
50-seat 1985 helicopter	11-20
98-seat 1985 helicopter	11-21
150-seat 1985 helicopter	11-22
50-seat 1985 tilt rotor	11-23
100-seat 1985 tilt rotor	11-24
150-seat 1985 tilt rotor	11-25

11.4.3.2 Analysis of 49-Seat 1975 STOL

The results of the 49-seat 1975 augmentor wing STOL intraurban system are analyzed in detail below. The analysis is useful in indicating the areas that are pertinent in achieving profitability or avoiding unprofitable operations. The data used in the analysis involve both direct and indirect operating costs and revenues but not depreciation and insurance of airplanes or STOLport facilities.

Figure 11-20 shows the relationship between total travel demand, demand available to the air mode, and demand actually carried by the intraurban air system. The total demand available to the air mode is about 1% of the total travel demand in the region. Of this, 80% is actually carried. Thus, 0.8% of the total person-trips in the study region are carried by the

air mode. Since more than half of the trips in the region cover distances of less than 8 mi (13 km), it is not surprising that the air mode carries such a small percentage of the total demand. As figure 11-20 shows, in the longer stage lengths, the air mode carries a respectable share of travel demand. In the 36- to 40-mi (56- to 64-km) range, the air system carries nearly 15% of all person-trips.

In the rest of this section, the operational aspects of the system will be studied. The first parameter investigated is the profit per node versus the number of links per node and passengers per node. In this analysis, the IOCs have been developed for each node and added to the DOCs and revenues. The direct operating costs and revenues have been taken from the link data and are shared equally between the two nodes served by the link. The profit per node data are presented in figures 11-21 and 11-22, where it will be noted that 10 of the 24 nodes are unprofitable. Of particular interest is the fact that the unprofitable nodes served only three or fewer links. It should be noted that it is impractical to design an intraurban transit system of this type and avoid the incorporation of nodes having less than four links. However, care should be exercised in the selection of STOLport locations so that the number of nodes possessing three or fewer links can be minimized. Similarly, some nodes serving few passengers must be included, but the number of such nodes should be minimized by careful selection of STOLports.

The traffic data were analyzed further by dividing the IOCs attributed to the STOLports between the links serving the STOLports. The costs were divided in proportion to the passengers carried on each of the links. Therefore, the cost of operating a link A-B is composed of the portion of IOC at node A, plus the portion of IOC at node B, plus the DOCs. The profit per link is then the difference between the revenue and the cost.

The links have been ordered in two ways: first, in order of decreasing profit and, second, in order of decreasing number of passengers carried. In both cases, a running sum of the profit and passengers carried has been made and converted into percentages of the maximum profit and maximum passengers carried. These data are presented in figures 11-23 and 11-24. Both the curves are similar in character with the maximum profit occuring for the first 50% of the passengers carried and zero profit at approximately 88%. The curve of decreasing profit produces the more optimistic maximum profit potential and also the smoothest curve. The most important point to note is that the last 14 to 16 links, which carry approximately 12% of the passengers, convert the operation from one that just breaks even into one that produces a loss of $7900 per day. This loss is equivalent to more than 90% of the maximum possible profit.

To determine which parameters are most closely associated with the profit potential of the links, the profit for each link has been plotted versus several pertinent parameters. The first parameter chosen is the load factor per link and the data are presented in figure 11-25. The interesting points that can be noted in the data are that no profitable links exist with a load factor less than 0.4 and, if the 14 most unprofitable links were eliminated with the cutoff load factor of 0.34, five other links would be eliminated.

When the profits per link are plotted against passengers per link, figure 11-26, the data are moderately correlated but not in the degree that the load factor could be correlated. For

instance, to eliminate the 14 most unprofitable links, a lower bound of at least 530 passengers per link would have to be used, but this would also eliminate 11 other links.

The profit per link was next plotted with revenue passenger miles (fig. 11-27), but here the correlation has all but disappeared. The reason for this is best seen from figure 11-28 where profit per link has been plotted with distance per link. In this case, there is no correlation whatever. The conclusion that can be drawn from this result is that the fare structure is not biased to favor one end or region of the range spectrum.

The last correlation made is between profit per link and number of flights per link, figure 11-29. Although a trend appears to exist, it is not possible to apply a constraint to eliminate the 14 most unprofitable links without also eliminating profitable links at the same time.

In summary, of the 65 links in the system, 20 links are profitable and 45 links are unprofitable. The 14 most unprofitable links produce a loss that is almost as large as the profit made by the leading 20 links. If these 14 unprofitable links were eliminated, all service to three STOLports (nodes 13, 21, and 24) would be lost.

11.4.4 Parametric Analysis

Even a casual reading of section 11.4.2, the description of the base case, could raise questions about some of the values chosen to define the base case. Some of these values may be critical, while others might have little effect on the system. In this section, the effects of varying some of these parameter values are discussed. In addition to studying the effects of changing the base-case parameters, effects of changing aircraft parameters (block speed and field length) and system parameters (elimination of ports) will be investigated.

Since the demand for air service determines, to a large extent, the size and type of aircraft required, it is important to calculate the effects of varying some of the parameters of the demand (mode-split) model. Values for most of the parameters used in the model can be determined with good accuracy, and no sensitivity studies are needed. However, the intercepts of the mode-split plane cannot be determined with complete certainty, so a sensitivity study was carried out.

Figure 11-30 shows the effects on total demand of a variation in the values of the three mode-split intercepts ΔC_0, ΔT_0, and Z_0, ΔC_0 is the cost difference that yields no demand to the air mode when the air and auto modes require the same trip time; ΔT_0 is the time difference at which 100% of the demand goes by air when the air and auto costs are equal; Z_0 is the percent of demand going by air when air and auto costs and times are equal. The 1980 STOL system is the basis of comparison. The results show that the demand is moderately sensitive to changes in all three intercepts. ΔC_0 is the most critical of the three, demand changes 2% for a 1% change in this variable. Demand changes by better than 1% for a 1% change in either of the other variables.

The effect of a 25% change in ΔC_0 is nearly equivalent to the effect of going from 1980 to 1990. The effects of the other intercepts are less pronounced but still significant.

This sensitivity of demand to the mode-split intercepts shows very clearly the need for further refinement of the demand model. This was not possible with the data available for this study.

Another parameter of the demand model that bears investigation is the passenger wait time. This is interpreted as the average length of time a passenger is required (by the aircraft schedule) to deviate from his desired departure time. The base case value was 10 min. Figure 11-31 shows the total demand for air service (1975 STOL system) using times of 5, 10, 15, 20, 25, and 30 min. As the figure shows, this is a critical variable. Going from 10 to 5 min increases the demand by 50%. With a 30-min wait time, the system shrinks to eight links and 6046 passengers.

The average passenger wait time used in the demand model must be consistent with that achieved in the network model. Larger wait times require lower frequencies and, if demand is constant, yield more profitable systems. Of course, demand is not constant, so the profitability of systems assuming various wait times must be tested with network model runs. Figure 11-32 shows the results of the network model on the demands generated by the demand model for wait times of 5, 10, 15, 20, 25, and 30 min.

The fare level influences both the demand and network models. Figure 11-33 shows how demand as a function of range varies as the fare goes from 70% to 120% of the base case (1980 STOL) fare. Figure 11-34 gives the same information for 1990. Clearly, the demand is very sensitive to fare; a 10% change makes a 30% difference in demand. Further, as expected, the lower fares produce their most dramatic increases in traffic for trips of 24 mi (39 km) or less.

Figure 11-35 shows the effect of fare level on the profitability of the system. It would appear that the base case fare could be lowered to reduce the loss per passenger. Figure 11-36 shows the effect of fare on operation of the system (load factor, utilization, etc.). Lower fares produce more dense segments and more segments overall and hence higher load factors and better utilization. The base fare is clearly preferable to a higher fare. It is not clear whether the 70% fare is better than the base fare. On the loss-per-passenger basis it is, but the extra absolute loss of $72 000 per day is not appealing.

Block speed, like fare, has an influence on both demand and system operation. The demand effect is clear, the faster vehicle picks up more demand. Figure 11-37 shows the magnitude of this effect for three 1980 STOL aircraft with cruise speeds of Mach 0.3, 0.4 and 0.591. Also shown in figure 11-37 is the number of segments (two-way) for which the daily demand exceeded 250 passengers. Figure 11-38 shows the effects of block speed on both demand and operation. As would be expected, the fastest vehicle produces the smallest loss per passenger as well as the smallest absolute loss.

The effects of gate time are shown in figure 11-39. The 1980 STOL system was run with gate times varying from the 3-min base case value to 11 min. Utilization drops and DOC rises. Revenue was held constant in all cases, so that the change in DOC directly represents a change in profit. As the curves show, gate time is an important parameter to minimize.

The effect of using degrees of "peaking" of demand different from those used in the base case was investigated by making a set of 15 network model runs. The 1980 STOL system was the base, demand in the morning and afternoon peaks was multiplied by various factors to accentuate or reduce the peak, the curves were normalized, and the network model was run. Figure 11-40 shows the effect on profit of the severity of the peaks. The abscissa is the multiplier used in the peak periods. A one means no multiplier (base curves), and zero means a completely flat curve. Profit means operating profit.

Several conclusions can be drawn from the curve. One is that the difference between flat curves and the base curves is significant (i.e., affects profit strongly). Another point is that increasing the severity of the peaking of the base curves by a factor of three has less of an effect than an equivalent reduction in the severity of the peaking. Finally, within a reasonable range (17 to 1.5), changing the severity of peaking has little effect. This last conclusion means that it is probably unnecessary to do extensive research to determine better the peaking characteristics of demand for intraurban transportation. Our current curves are probably good enough.

The sensitivity of the intraurban system to technology was studied by comparing the 1975 STOL and helicopter vehicles with their 1985 equivalents operating on 1990 demands. For the STOL vehicles, both 1975 and 1985 versions had the same demand and block speed. Hence, their schedules were identical. Figure 11-41 shows that the difference in loss between the two aircraft is due wholly to the DOC reduction. The difference in loss per passenger is about 10%.

For the helicopter, the technology effect is more striking. Not only does the 1985 aircraft have lower operating costs, but it also has a block speed advantage. Thus, the 1985 version gets a larger share of the travel demand. As figure 11-41 shows, the 1985 version makes a significantly greater operating profit than does the 1975 aircraft. Further, the 1985 aircraft loses 40% less per passenger than does the 1975 helicopter.

The sensitivity of system profit to field length capability is shown in figure 11-42. This chart was produced by considering the revenue and schedule fixed at the 1980 STOL base-case level. The effects of field length increases and decreases on DOC and terminal investment were calculated. The results indicate that the savings on terminal investment for shorter field lengths more than offset the increase in DOC for the additional capability.

Since STOLport 1, the downtown San Francisco STOLport, carries over 30% of the total system demand, and since this STOLport is expensive to build, the effect of eliminating it was investigated. Figure 11-43 shows the effect on profit of dropping STOLport 1. Remarkably, the loss in demand from eliminating STOLport 1 is negligible. It turns out that STOLport 3 is nearly as convenient as STOLport 1. The effect of eliminating STOLport 1 is to reduce the loss per passenger by approximately 6%.

The effects of eliminating STOLports 1 and 3 and STOLports 1, 2, and 3 were also investigated. The results are shown in figure 11-43. Both of these attempts increased the loss per passenger over that obtained with just STOLport 1 eliminated.

In all of the base cases, and for all sensitivity studies discussed so far, it was assumed that the air system was competing with auto and conventional transit systems. BARTD was not considered. A case was run through the demand model using three competing modes: STOL, BARTD, and auto. The resulting demand for STOL is compared with the base-case demand for STOL (without BARTD) in figure 11-44. The resulting demand was run through the network model. Figure 11-45 shows the results. As would be expected, BARTD, with an average fare of $0.05/mi and 50 mph (80 km/hr) average speed is a strong competitor. Of course, this does not mean that BARTD was a better investment for the Bay area than a V/STOL system. To answer this question involves analyzing the true costs of both systems including the $1.3 billion initial investment in BARTD.

11.5 ECONOMIC ANALYSIS

11.5.1 Comparisons of Systems

It will be noted that, as a result of the cost of debt and depreciation, all of the vehicle systems incur a loss. Therefore, economic comparisons are presented in terms of relative loss (instead of profit).

Two criteria, namely, annual system loss and loss per person-trip, were selected to be used as economic measures for the evaluation of alternative aircraft systems.

The network model was used to examine 15 base aircraft systems:

- Six aircraft systems in 1980 (tables 11-26 through 11-30)
- Nine aircraft systems in 1990 (tables 11-31 through 11-35)

The 1980 and 1990 operating years were used so as to coincide with the projected traffic data years and may be considered as representative mature years of service for the respective state-of-the-art vehicles. Aircraft designed for 1975 and 1985 were used, respectively, for the 1980 and 1990 systems.

To fulfill one of the objectives of the study, the network model was exercised to determine the most suitable aircraft in the STOL and VTOL categories for use in the 1975-85 and 1985-95 time periods. Based on the economic measures shown in tables 11-30 and 11-35 (displayed graphically in figures 11-46 and 11-47), the following aircraft selections are made:

Year of Operation	Best STOL	Best VTOL
1980	49-seat augmentor wing	50-seat helicopter
1990	49-seat augmentor wing	50-seat tilt-rotor

Year of Operation	Best Aircraft
1980	50-seat helicopter
1990	50-seat tilt-rotor

As stated in section 8.4.9, the initial terminal investment is equal to land costs plus only those facility costs directly attributed to the operation of the transportation of passengers. This excludes the cost of providing concession space (restaurants, auto rental, stores, office space, advertisements, etc.), which is assumed to be financed by private funds.

A minimum of 2% spare aircraft is added to allow for dispatch reliability. The basic aircraft requirement is based on the greater of the demand between the morning and afternoon peaks. At any other time of day the actual aircraft that are in excess of requirements greatly exceeds this 2%. As noted in section 8.4.8, no spare aircraft are required for scheduled maintenance.

Tables 11-29 and 11-34 show that deposits into sinking funds, one for fleet replacement and the other for terminal facility replacement, account for the annual depreciation cost associated with initial investment. In the sinking-fund method of amortization, one of a series of equal amounts is deposited into a sinking fund at the end of each year of life of an asset. The amount the investment is amortized during any year is the sum of (1) the amount deposited and (2) the amount of interest earned on the sum on deposit in the sinking fund during the year. Investment amortization is equivalent to amortization of debt equal to the total depreciation that would occur during the life of the asset. For example, total depreciation of the fleet is assumed equal to 85% of the initial fleet investment, where the fleet would be totally depreciated in 10 years with a salvage value equal to 15% of the original investment. Each time the sinking fund is filled, assets are replaced with the money accumulated.

Each of the tables is self-explanatory. The data were obtained from the network model or, as noted in the footnotes, either from other sections of this report or other external sources. The methodology is hopefully straightforward. For example, the investments shown in table 11-28 and 11-33 were determined from the required fleet size, aircraft and spare parts costs, and the forecasted cost of air terminals. The cash flows in tables 11-29 and 11-34 account for operating profits (or losses), debt interest charges, and sinking fund deposits for future asset replacement. Sinking funds and interest on investment for the nonaviation portion of the ground facilities (cash outflow) and nonaviation profits (cash inflow) are not shown because they are assumed to be equal and hence cancel each other. Debt retirement (cash outflow) is not accounted for as a continual debt is assumed (see section 11.5.2 for different assumptions.) The last tables (11-15 and 11-20) simply allocate the system loss to population, population over 18 years old, and person-trips via air.

11.5.2 Sources and Applications of Funds

Because tables 11-29 and 11-34 show that operating profit is not sufficient to supply the required cash for debt costs and the sinking funds, outside sources of cash are needed. Possible sources of funds include local and federal subsidies and grants and income to the intraurban system from concessions and leases. To show where the necessary cash might be obtained, a financial cash-flow working statement has been prepared for each of the four best aircraft systems (tables 11-36 through 11-39). Five possible cash flows (A, B, C, D, and E) are postulated for illustration:

A No federal support; no concession or lease income to intraurban system.

B No federal support; concessions and leases = 1/2(terminal-associated bond interest + terminal sinking fund deposit).

C No federal support; concessions and leases = terminal-associated bond interest + terminal sinking fund deposit.

D Federal grant - 2/3(total investment); concessions and leases = 1/2(terminal-associated bond interest + terminal sinking fund deposit).

E Same as D except for the addition of annual subsidy in "matching" federal funds.

Terminal-associated bond interest is that portion of the annual interest payment allocated to the investment in land and ground facilities. Note that, in cash flows D and E, the "terminal-associated bond interest" is one-third of that in cash flows A, B, and C. This is due to the two-thirds reduction in bond debt as a result of the federal grant. The term "matching" federal funds in method E refers to an annual Federal subsidy equal to the local governmental subsidy.

Concession and lease indirect profit historically has been used to defray the aviation-oriented cost at major airports. Reference 33 and other studies have shown that proposed elevated metroports can have substantial nonaviation net income that, in some cases, can meet all aviation-oriented cost. Cash-flow A is very conservative in that no concession and lease net income occurs; the other cash-flow illustrations assume concession and lease net income of 50% (B, D, E) and 100% (C) of annual terminal costs.

The basis for postulating a two-thirds federal grant is recent mass transit planning. As an example, a federal grant of approximately this magnitude was assumed for the recently defeated Seattle proposed mass transit system.

Subsidies are required to provide cash in all five possible cash flows (A, B, C, D, and E) for the four systems, except for cash-flow C, D, and E associated with the 1990 50-seat tilt-rotor VTOL (table 11-37). In fact, flows C, D, and E for the VTOL provide a surplus of cash from the inflows of operating profit and concession and lease income. If one of these flows were to actually occur, the 1990 VTOL system would be a profitable venture.

If a single cash-flow outcome had to be forecast, it is believed that cash-flow D is the most probable. Here, a federal grant (possible source: HUD) would provide the initial stimulus; thereafter, any necessary financial support would have to come from the local communities.

Figures 11-48 through 11-52 compare graphically the STOL and VTOL systems operating under each of the suggested cash flows.

11.6 BARTD COMPARISON

Although the primary motive for any modern mass public transportation system is to replace all or part of automobile traffic in a given area, it is inevitable (and proper) that the competing methods of mass transit be compared. In the San Francisco area, the Bay Area

Rapid Transit District (BARTD) is scheduled to begin initial service in the fall of 1971. It seems appropriate, then, to compare the aircraft intraurban system with BARTD. The data presented here for BARTD come from references 2 and 3.

Some pertinent characteristics of BARTD:

- 75 mi (120 km) of track connecting 33 stations in three counties
- Approximately 200 000 estimated daily passengers in 1975
  - 80 000 San Francisco local
  - 72 000 transbay
  - 48 000 east bay local
- Daily revenue passenger miles–1 760 000 (2 830 000 passenger km)
- Average trip length–approximately 9 mi (14.5 km)
- Average fare–approximately \$0.45 (\$0.05/mi–\$0.031/km)
- Passengers previous mode:
  - Transit–approximately 70% (140 000)
  - Auto–approximately 30% (60 000)
- Initial investment–approximately \$1 300 000 000
- Annual revenue (1975)–approximately \$25 000 000
- Annual cost to taxpayers–approximately \$100 000 000 (includes debt repayment)

Similar items for the base-case intraurban:

- 1550 mi (2490 km) of routes connecting 24 terminals in nine counties
- Approximately 50 000 estimated daily passengers in 1980
- Daily revenue passenger miles–1 140 000 (1 830 000 passenger km)
- Average trip length–approximately 23 mi (37 km)
- Average fare–\$3.60 (\$0.155/mi–\$0.0974/km)
- Passengers previous mode–auto approximately 100%
- Initial investment–\$745 000 000–STOL (\$412 000 000–VTOL)

- Annual revenue (1980)–$55 000 000–STOL ($59 000 000–VTOL)

- Annual cost to taxpayers–$48 000 000–STOL ($35 000 000–VTOL)

Figure 11-53 shows the distribution of the BARTD 200 000 daily trips versus trip length in 4-mi (6.3-km) intervals. Superimposed are the same data for the base-case intraurban system in 1980. The BARTD system is primarily a short-range system, carrying 85% of its passengers less than 16 mi (25.7 km), while the airplane system carries 83% of its passengers more than 16 mi (25.7 km). It is estimated that both systems capture about the same auto passengers (60 000 versus 50 000), although the automobile road miles saved by the airplane system will be twice that saved by BARTD, due to the much longer average range of the airplane system.

BARTD carried four times the number of passengers carried by the intraurban system. However, in productivity (revenue passenger miles), BARTD is only 50% higher than the intraurban system. The initial investment for BARTD is 75% to 200% more than the intraurban system resulting in an annual cost to the taxpayers of 100% to 200% more.

The fare for BARTD varies from a $0.25 minimum charge to a $1.00 maximum charge averaging about $0.05/mi ($0.031/km) for the system. This closely approximates the incremental cost of operating an automobile whose depreciation and insurance are being charged elsewhere. The fare at the average range for the intraurban system is $3.50 or about $0.15/mi ($0.095/km). This is within the range of various estimates of the total cost of operating an automobile. This illustrates the relative intent between the BARTD fares and the intraurban fares.

BARTD fares were aimed at satisfying existing transit patronage, the only way to obtain the very large number of passengers needed for a ground-based system. The intraurban fares were aimed at capturing the single-occupant automobile commuter. BARTD cash operating costs are only about 12% of the total cost, including debt service, paid by the taxpayers. Since only these cash costs vary with the number of passengers carried by the system, maximum community service is achieved if the fare is kept low and large numbers of people utilize the system. Then the large loss ($100 000 000 cost to taxpayers) is spread over a larger base. The loss per person carried on the BARTD system (estimated for 1975) is about $1.70. If the fare were raised by that amount, the shrinkage in passenger traffic indicated by the relationship shown in reference 11-2 would be nearly 100%. Needless to say, the resulting loss per passenger carried would be quite large.

For the intraurban system, the cash operating costs are approximately 43% of the total costs, including debt service. With this much higher percentage of costs being proportional to the number of passengers carried, a different relationship occurs. This is illustrated in Figure 11-54. If the intraurban system used the BARTD revenue, the annual system losses would increase rapidly.

As the reader has observed, it is difficult to find one parameter on which to base the total comparison between an airborne system and a ground system. The ground-based systems are at their best over very short ranges with very dense populations along the route capturing most of their passengers from present transit users. The airborne system is at its

best at the longer intraurban ranges, offering fast transportation to a much greater area, and capturing most of its passengers from the automobile.

The airborne system offers the additional advantages of rapid response to community needs and freedom from community-disrupting ground corridors. While BARTD will take 10 years from the first bond issue voted by the people until initial passenger service, an aircraft system would require only about 5 years. To expand BARTD down the west bay would take a minimum of 4 years, yet additional airborne links can be added by simply building one more terminal. This might take 6 months for an existing airport site or perhaps 2 years for a complex elevated structure.

It would seem then, that an optimum mix between a ground and an airborne transportation system could be found. For the very densely populated areas, short-range ground systems could serve where the bus serves today. The aircraft system could then provide an alternative to the automobile at ranges from 15 to 40 mi as well as expand the distance a commuter was willing to travel as discussed in section 11.7. It was not the intent of this study to find such a mix, but the potential benefits of a well integrated system of air and ground transportation demands that a study be made. Such a study could also be expanded to include the integration of intercity transportation facilities with those of the air and ground intraurban systems.

11.7 NETWORK PROGRESSION

While this study is concerned mainly with representative mature years of operation in two reference time periods, the manner in which the networks evolve with time is important. When such a metropolitan air transport system is contemplated for a given region, planners will have to identify the network components in some rational order of development.

Since considerations of economic feasibility tend to modulate the response to transportation demand, network progression can be described, within limits, by an examination of node and link relative economics.

Table 11-40 lists the first 15 network links in order of operating profit potential. The associated nodes can be extracted in similar ranking.

On this economic basis, which may be slightly modified by consideration of relative total system cost factors, one strong inference can be drawn. If profit potential governs, the initial networks must certainly serve San Francisco city.

However, economic criteria are not the only bases for the order of node and link selection. For example, in table 11-40, the first 10 links do not all close to form logical networks, and an examination of the traffic flows would show that there is substantial directional imbalance. Therefore, in addition to profit, network development must be based on balanced flows, or load factors will be unnecessarily low.

Another interesting aspect of the top group in this example is that, with the exception of the dominating downtown San Francisco location, all of the top 10 links serve existing airports.

Under other circumstances, network evaluation could be constrained by consideration of port development costs when several "downtown" locations might tap large traffic sources.

Thus, network progression should be based on some or all of the following criteria:

(1) Link economic feasibility

(2) Link/network/traffic flow compatibility

(3) Relative node investment levels and community compatibility

(4) Availability of traveler options

For any given vehicle class, time frame, and public pressure, these rules may be applied to determine the rankings and timing of network elements.

11.8 GENERAL APPLICABILITY

The choice of the San Francisco Bay area as one of the sites of a metropolitan air transport systems anlaysis was logical. It is the locale for one of the most ambitious mass transit systems to be developed domestically in recent years. It has had a substantial regional transportation planning activity for a number of years. It is located in a state where auto registrations per capita are 60% greater than in a similarly populated East Coast state and where (possibly consequentially) regional environmental concern is at a high level.

However, the sponsors of the study were conscious of the special topographic characteristics of the area (dominated by a large bay occupying about 400 sq mi and long ranges of hills on both sides of the bay). As a result, they were anxious to know to what degree the results of the study were applicable to other metropolitan regions.

The initial reaction is to assess the influence of cross-bay traffic on the economic outcome of the analysis, and undoubtedly there would be some impact, even though the study route structure features many overland routes. A more important consideration is that the water-covered area of the region disperses population substantially. If the Bay were filled and populated at the same density as San Mateo County, for example, the fringe area population of the nine counties could be contained—with a profound change in the long-range commuter trip requirement.

For this reason, it is difficult to prescribe a demographic criterion by which the study results could simply be applied to other metropolitan centers. Furthermore, even if the topographical features were similar, a population-based criterion would provide only a crude indication of fleet size and would not sense the need for service.

In reference 34, Voorhees and Bellomo have shown how work opportunities have changed as a result of speed improvements in urban travel. Figure 11-55 shows the substantial shift in job opportunity resulting from a nominal 50% speed increase. The impact of this change is better appreciated in conjunction with figure 11-56 (from the same reference), which shows an example of population density as a function of travel time. The speed increase from the first figure would tend to increase the distance associated with the travel times in the second graph. It is then possible to predict a shift in the population density curve permitting an increase in external population density, as shown in figure 11-57. In this case, judgmental speeds have been applied to the figure 11-56 values and translated into distance. Note that the lower population density values with increased speed enclose an area almost three times that of the slower condition.

From the foregoing, it can be concluded:

(1) The present study cannot be directly applied to another metropolitan complex by reference to a simple demographic criterion (population, area/density ratio, etc.).

(2) In general, a high-speed system tends to expand the job opportunity area of the central business district (CBD). To the extent this is considered socially desirable, the metropolitan air transport system is a reasonably cost-effective (dollar-per-passenger) method of accomplishing this purpose.

(3) Where topographical barriers exist, the above conclusion is even more emphatic.

TABLE 11-1.—COMPARABLE 10-TON PAYLOAD VEHICLES

Distance[d]		Air[a]		Surface[b]		Comparison—
st mi	km	Trip cost/ avail ton, $	Trip time, hr[c]	Trip cost/ avail ton, $	Trip time, hr	cost per ton/ hr saved, $
10 (12)	16(19)	[e]5.60 (56¢)	0.43	[e]1.20 (12¢)	0.5	63.00
20 (24)	32(39)	6.30 (31¢)	0.46	2.40 (12¢)	0.8	10.50
50 (54)	80(88)	8.40 (17¢)	0.52	5.40 (11¢)	1.55	2.80
100 (104)	161 (168)	11.70 (12¢)	0.68	10.40 (10¢)	2.55	0.81

[a]Air costs include only flight-oriented direct expenses (crew, fuel, and all maintenance) $49.00 + $0.70/st mi (for conversion configuration).

[b]Truck costs based on $1.00/road-mile (conservative for intercity operations).

[c]Includes 20-min load and unload cycle.

[d]Parentheses indicate assumed road mileage.

[e]Available ton-mile cost.

TABLE II-2.—1980 STOL DEMAND (MATRIX 1)

USE FOLLOWING FORMAT TO READ THE DEMAND MATRIX BELOW FOR THE STOL PORTS.

DEMAND FROM STOL PORT TO ------------------------------ TO STOL PORTS ------------------------------ TOTAL DEMAND FROM STOL PORT

THE FOLLOWING IS THE DEMAND MATRIX WITH MODE SPLIT.

1	[illegible]			1	229	183	375	11	145	0	13	1	47	122	352
	374	232	116	[illegible]	158	22	31	0	21	0	11	0	0	65	175
	2341														
2	[illegible]		1	0	190	555	539	173	235	16	48	2	36	114	396
	467	292	127	0	186	18	49	0	33	0	27	0	0	150	328
	4351														
3	[illegible]		0	0	37	185	381	91	185	17	43	1	41	128	234
	157	34	89	0	126	17	25	0	11	0	4	0	0	76	69
	2313														
4	7		3	0	14	311	623	143	247	21	63	2	30	80	279
	317	307	139	0	130	9	13	0	4	0	7	0	6	34	122
	2127														
5	475	79	91	9	0	98	271	227	507	66	235	0	31	106	217
	166	374	164	0	134	8	9	0	6	0	4	0	0	22	151
	2417														
6	2162	27	517	135	138	0	1	73	404	106	376	36	79	196	273
	225	329	89	1	29	3	3	0	3	0	2	1	0	5	95
	5337														
7	[illegible]	219	493	180	780	1	9	1	119	53	136	39	7	5	53
	106	87	14	9	6	0	1	1	0	0	0	1	0	1	16
	4177														
8	976	171	741	114	425	216	1	0	92	33	115	42	13	24	167
	169	87	14	0	6	2	1	0	[illegible]	0	0	0	0	1	9
	2910														
9	1174	16	646	164	988	758	156	49	1	53	0	46	44	176	549
	643	304	49	1	49	5	4	0	1	0	0	0	0	3	11
	4926														
10	914	43	99	36	243	381	154	55	174	0	51	5	17	97	169
	176	107	19	0	12	1	0	0	0	0	0	0	0	0	5
	1372														
11	717	53	214	59	499	761	496	178	0	35	0	14	48	219	528
	461	271	35	0	41	3	3	0	1	0	0	0	0	1	3
	4193														
12	[illegible]	42	131	25	232	543	957	394	403	29	233	1	45	356	283
	915	158	29	0	20	1	0	0	0	0	0	0	0	0	0
	[illegible]														
13	[illegible]	[illegible]	275	55	152	173	79	59	155	19	89	10	0	14	163
	309	211	31	0	112	7	22	0	9	0	1	0	0	2	9
	[illegible]														
14	998	17	457	111	793	317	77	77	343	73	277	65	8	0	159
	795	247	101	0	133	10	[illegible]	0	5	0	0	0	0	2	13
	5112														
15	1366	419	746	236	438	447	117	193	791	51	153	41	50	123	3
	143	407	349	[illegible]	116	26	42	0	14	0	2	0	0	4	69
	[illegible]														
16	[illegible]	225	335	171	773	270	225	137	501	36	247	12	81	295	57
		10	136		96	67	51	0	24	0	4	0	0	6	75

TABLE II-2. –1980 STOL DEMAND–Continued
(MATRIX 1)

	4579															
17	782	2?5	276	147	424	3?6	161	55	229	15	114	6	65	260	242
	29	[illegible]	4	0	59	64	22	0	53	0	9	1	0	5	45
	3542															
18	827	166	723	111	791	188	113	71	79	5	71	3	78	174	341
	327	12	0	0	79	68	4	0	79	0	8	0	0	2	11
	3286															
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0															
20	2260	422	935	192	443	155	117	73	187	11	83	6	96	196	231
	323	225	168	0	0	41	44	0	75	0	21	0	0	41	72
	6251															
21	579	85	233	28	93	43	32	10	45	3	13	1	8	72	92
	279	444	215	0	69	0	73	0	72	0	15	0	0	11	16
	2445															
22	525	170	202	43	84	35	26	7	24	1	11	1	23	22	92
	190	84	5	0	23	33	0	0	1	0	55	1	0	7	95
	1595															
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0
	[illegible]															
24	561	188	246	42	96	38	15	2	12	0	3	0	19	17	71
	271	475	155	0	150	37	0	0	0	0	55	0	0	20	224
	2784															
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0															
26	542	241	197	47	75	23	3	0	0	0	0	0	1	0	8
	36	117	53	0	47	8	191	0	97	0	0	0	0	48	265
	2182															
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0															
28	0	0	0	0	0	0		0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0															
29	1513	547	485	153	248	106	82	15	17	0	2	0	7	6	25
	67	9	8	0	108	21	39	0	33	0	26	0	0	0	0
	3508															
30	1741	477	456	189	581	393	233	43	63	4	12	0	9	22	138
	244	161	13	0	70	11	34	0	100	0	71	0	0	0	0
	4715															

TABLE II-2.—1980 STOL DEMAND—Continued
(MATRIX 2)

THE FOLLOWING IS THE DEMAND MATRIX WITHOUT MODE SPLIT.

1	227741	34887	32711	19361	16294	4153	1543	420	417	30	49	3	282	413	2246
	8105	16770	2656	1	1775	85	153	0	99	0	34	0	0	569	5467
	645776														
2	193112	227276	111362	71024	72715	7621	2997	742	713	61	175	4	243	439	3518
	4461	15921	2529	0	1195	76	231	0	184	1	44	0	0	1098	17066
	711596														
3	111764	63946	119254	33995	33522	6483	2589	533	556	92	147	4	344	579	3715
	10623	57316	2693	1	1366	88	141	0	54	0	12	0	0	217	3117
	426932														
4	67544	54461	73727	110132	61752	9548	3573	780	934	96	170	6	232	359	1997
	6120	9697	1324	0	642	36	71	0	41	0	22	0	0	245	2478
	413473														
5	45772	19875	46627	53701	139278	91342	11752	2945	3217	529	939	35	296	886	3410
	6517	9543	1324	0	744	31	39	0	23	0	11	0	0	161	1513
	486496														
6	22144	4766	17611	6553	94930	375604	82756	22657	12943	2045	2364	198	455	2936	5654
	3114	3114	463	0	228	12	9	0	9	0	4	0	0	29	459
	669131														
7	5064	534	2221	934	9765	64366	203295	43294	30125	2787	4873	332	311	3825	3726
	1271	736	67	0	63	2	3	0	1	0	5	0	0	4	51
	377762														
8	3314	584	1797	732	5517	31568	113426	151549	94919	12417	12453	592	353	2916	1417
	672	384	43	0	46	8	3	0	0	0	0	0	0	2	27
	433698														
9	2994	457	2772	572	4663	18397	82521	109049	561764	60148	143130	3692	2229	19998	6309
	3129	1897	165	0	325	22	10	0	2	0	0	0	0	8	29
	1132469														
10	772	161	433	164	1747	6514	23333	27837	110695	82020	37099	12411	416	3021	1461
	541	402	50	0	69	5	1	0	0	0	0	0	0	0	12
	316352														
11	857	135	617	168	1684	5853	21381	19161	190772	22331	233693	9351	1313	10946	3770
	1798	1134	134	0	279	15	9	0	3	0	0	0	0	3	8
	525194														
12	349	8	269	64	737	2479	8563	5247	30153	23066	41799	107816	401	2674	1230
	644	474	51	0	72	3	1	0	0	0	0	0	0	0	0
	221412														
13	2366	581	2042	357	1111	1529	2353	1062	4773	374	2222	116	85559	9724	27876
	12412	3053	1249	0	22882	1130	332	0	166	0	6	0	0	20	45
	190328														
14	3127	619	2175	432	2025	6122	15262	5286	26532	1762	11519	519	7815	155285	53379
	13829	7596	973	0	1716	94	48	0	22	0	1	0	0	7	38
	315659														
15	12172	2657	12510	1723	5855	9175	9215	2014	8306	709	3243	197	13603	44560	393962
	124364	44397	4443	0	4895	751	767	0	95	0	8	0	0	20	271
	735964														
16	23111	5934	31793	3366	7091	3310	2682	618	2493	193	1953	42	4171	6669	87878
	454474	231135	17787	1	17011	755	786	0	312	0	13	0	0	93	734
	971316														
17	35476	7488	31489	3295	6031	2119	1159	245	1313	54	415	17	2339	2477	13244
	135543	522029	89183	1	22368	1022	2077	0	369	0	43	0	0	214	1303
	1067974														
18	17378	2706	7824	1117	2167	722	380	66	253	14	92	7	689	715	4321
	24903	115990	192597	1	12019	1116	5921	0	1347	0	110	0	0	404	1389
	312463														

TABLE II-2.–1980 STOL DEMAND–Continued
(MATRIX 2)

19	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
20	15371	2773	4393	1135	2612	978	865	247	1071	61	479	26	27578	1978	11514
	76242	70157	13987	0	335769	46377	17420	0	5121	0	335	0	0	659	679
	99618														
21	2225	36	1174	117	766	168	207	69	259	15	117	5	3946	324	1576
	3722	7798	3240	0	56570	74569	2051	0	14733	0	111	0	0	148	175
	173418														
22	2674	477	1219	193	731	114	91	13	73	3	23	0	435	97	716
	2746	8359	11413	0	21743	1276	111677	0	13394	0	464	0	0	2098	1773
	194457														
23	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	3178	1124	1734	220	306	124	49	6	35	0	12	0	422	77	450
	2342	7724	7585	0	12347	14457	34245	0	177527	0	15351	0	0	6664	4736
	210545														
25	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	1048	852	592	140	220	58	7	0	0	0	0	0	12	1	34
	149	514	574	0	678	85	2045	0	13712	0	232566	0	0	21212	3782
	[illegible]														
27	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	11176	5255	3065	1063	1297	384	231	40	43	1	5	0	55	21	130
	540	1878	1917	0	1602	193	5458	0	5433	0	12371	0	0	77232	54581
	197977														
30	44890	33476	12986	5042	5474	1770	775	132	173	11	33	1	47	74	637
	2624	6013	3957	0	847	76	2221	0	2238	0	1549	0	0	32690	171341
	[illegible]														

TABLE II-2.—1980 STOL DEMAND—Continued
(MATRIX 3)

THE FOLLOWING IS A BALANCED DEMAND MATRIX WITHOUT MODE SPLIT.

1	0	232508	204465	85905	61526	26257	7592	3474	7411	732	456	347	3237	3440	14416
	351.6	52214	16594	0	16446	2360	2737	0	3277	0	2932	0	0	19645	51357
	923381														
2	232209	0	165006	135475	52194	12416	3871	1326	1176	221	261	84	824	1558	5175
	14395	23810	5236	0	3915	478	838	0	1318	0	946	0	0	6355	53582
	779917														
3	214415	165016	0	118622	74549	19494	4369	2240	2928	515	764	254	2336	2753	14215
	51022	53695	13517	0	9660	1262	1360	0	1338	0	614	0	0	3262	13163
	759413														
4	85905	135475	118622	0	115154	16201	3982	1482	1436	260	338	70	559	781	3720
	9426	11992	2421	0	1777	153	254	0	361	0	168	0	0	1378	7520
	675195														
5	61526	52194	74549	115054	0	190281	21517	8462	7810	2275	2523	772	1407	2911	3265
	12528	14644	3467	0	3266	381	369	0	425	0	220	0	0	1448	6944
	591214														
6	26257	12416	19494	16201	190281	0	147142	43725	29040	8554	9822	2676	1973	9060	14789
	6464	5273	1155	0	1166	180	122	0	133	0	62	0	0	413	2229
	547463														
7	7592	3871	4369	3982	21517	147142	0	156720	110646	23087	26254	8895	2664	19087	11941
	3883	1845	447	0	928	209	94	0	50	0	7	1	0	275	829
	556184														
8	3474	1326	2240	1482	8462	43725	156720	0	203859	40224	31613	5839	1415	8202	3431
	1293	629	119	0	202	77	22	0	6	0	0	0	0	42	159
	514579														
9	7411	1176	2928	1436	7810	29040	110646	203859	0	176984	331312	33945	6782	45630	14605
	5588	2503	418	0	1403	281	83	0	37	0	0	0	0	57	268
	971322														
10	732	221	515	260	2275	8554	23087	40224	176884	0	59301	35477	790	4783	2170
	879	466	64	0	130	20	4	0	0	0	1	0	0	1	23
	356354														
11	456	261	764	338	2523	8822	26254	31613	331302	59301	0	59449	3535	22564	7060
	2351	1549	136	0	768	122	37	0	15	0	0	0	0	8	28
	550866														
12	343	84	264	70	772	2676	8895	5839	33945	35477	59449	0	517	3153	1427
	686	491	59	0	98	8	1	0	0	0	0	0	0	0	1
	145154														
13	3237	824	2336	559	1407	1979	2664	1415	6782	790	3535	517	0	17539	41479
	16543	12292	1937	0	46410	5016	767	0	588	0	18	0	0	75	92
	168891														
14	3440	1558	2753	781	2911	9560	19087	8202	45631	4783	22564	3153	17539	0	97939
	20498	10073	1675	0	3294	432	145	0	93	0	2	0	0	28	112
	275258														
15	14416	5175	14215	3720	9265	14789	11941	3431	14605	2170	7060	1427	41479	97939	0
	216242	63641	9764	0	15309	1897	983	0	576	0	42	0	0	150	908
	553104														
16	351.6	14395	51022	9486	17008	6464	3883	1293	5516	879	2351	686	16543	20498	216242
	0	435687	42710	0	53253	4487	3572	0	2694	0	187	0	0	733	3358
	997178														
17	52214	23810	53695	11992	14644	5273	1845	629	2503	460	1549	491	12292	10073	63641
	435687	0	235182	0	132625	6820	10472	0	8183	0	551	0	0	2092	7316
	1392264														
18	16594	5235	13517	2421	3467	1155	447	119	418	64	136	59	1937	1675	9764
	42710	235182	0	0	31606	4256	17334	0	9482	0	649	0	0	2321	5346
	473317														

TABLE II-2.—1980 STOL DEMAND—Continued
(MATRIX 3)

19	0 0 0		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
20	16446 53253 456275	1519 112625	9661 31606	1777 0	3316 0	1166 103277	924 39213	293 0	1413 17763	170 0	718 773	98 0	46410 0	3294 2261	15399 1526
21	2369 4497 171536	478 382	1262 4256	153 0	781 113277	160 0	209 3927	77 0	281 [illegible]	20 0	122 214	9 0	5116 0	432 371	1897 212
22	2767 3672 151116	808 11432	1361 17314	254 0	369 39213	122 3927	94 0	22 0	33 54193	4 0	37 2363	1 0	767 0	145 7556	983 3994
23	0 0 0		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
24	3277 2574 142229	1318 1167	1398 1482	261 0	425 17368	133 33266	50 54199	6 0	37 1	0 0	15 29553	0 1	538 0	99 12437	576 5974
25	0 0 0		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
26	2172 187 77455	946 561	604 689	169 0	220 773	62 214	7 2963	0 0	0 29563	0 0	0 0	0 0	18 0	2 33083	42 5331
27	0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
28	0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
29	15645 733 172162	6355 2082	3282 2321	1308 0	1448 2261	413 371	235 7556	42 0	57 12437	1 0	8 33083	0 0	75 0	28 0	150 87271
30	51387 3382 257757	50512 7310	15103 5345	7520 0	6944 1526	2229 212	829 3994	159 0	293 6974	23 0	33 5331	1 0	92 0	112 87271	908 0

TABLE II-2.–1980 STOL DEMAND–Continued
(MATRIX 4)

THE FOLLOWING IS A BALANCED DEMAND MATRIX WITH MODE SPLIT.

1	0 1445 23776	[illegible] 1014	[illegible] 937	4 0	854 2448	2525 601	2145 556	947 0	1219 672	223 0	336 652	177 0	555 0	1047 1568	2346 1515
2	0 772 8467	[illegible] 597	0 288	0 0	269 668	825 113	757 159	304 0	344 221	59 0	99 263	34 0	128 0	284 651	815 785
3	0 482 9610	[illegible] 416	0 419	0 0	128 962	692 [illegible]	973 357	477 [illegible]	971 255	116 0	261 134	132 0	315 0	565 516	979 714
4	4 467 5766	[illegible] 439	0 229	0 0	23 282	446 38	813 61	257 0	411 50	57 0	119 54	27 0	96 0	181 194	516 311
5	854 674 11147	269 907	128 514	23 0	0 668	236 161	1053 93	652 0	1695 111	311 0	774 79	241 1	183 0	399 269	655 732
6	2525 614 12346	825 623	692 256	446 0	236 184	0 46	1 39	279 0	1252 41	487 0	1197 24	589 0	212 0	412 112	677 478
7	2145 342 9344	757 246	973 127	803 0	1050 123	1 33	0 27	2 0	265 15	191 0	635 3	115 0	87 0	32 83	229 249
8	947 306 4950	304 144	432 35	257 0	652 39	279 12	2 8	0 0	173 2	87 0	253 0	436 0	52 0	50 15	365 52
9	1219 1119 11656	784 593	871 126	411 0	1685 236	1252 50	265 28	130 0	0 12	197 0	0 0	918 0	239 0	485 19	1321 74
10	223 174 2549	59 123	116 23	57 0	311 23	487 4	191 1	87 0	197 0	0 0	87 0	34 0	36 0	175 0	241 9
11	336 648 6811	49 379	261 66	119 0	774 130	1097 23	635 13	253 0	0 4	97 0	0 0	257 0	137 0	496 3	971 15
12	177 227 5019	34 165	102 22	27 0	241 26	589 2	1005 0	436 0	913 0	34 0	257 0	0 0	55 0	425 0	324 0
13	555 481 3578	129 431	315 128	56 0	183 196	212 15	87 45	52 0	239 29	36 0	137 1	55 1	0 0	23 9	221 17
14	1347 1312 7656	294 1037	565 325	181 0	399 330	412 47	32 35	60 0	495 22	175 1	496 0	425 0	23 0	0 8	261 34
15	2744 144 12496	815 695	979 769	506 0	655 747	677 118	221 134	365 0	1371 55	241 0	971 11	324 0	221 0	261 28	0 206
16	1415 0 11134	737 47	492 483	497 0	670 413	534 325	332 231	296 0	1119 335	174 0	538 41	227 0	480 0	1012 73	199 319
17	1134 47 9473	597 0	415 15	439 0	808 274	633 498	246 136	144 0	993 524	123 0	379 125	165 0	431 0	1007 95	695 236
18	927 487 5584	248 16	418 0	229 0	514 247	256 273	127 9	35 0	175 133	23 0	65 62	22 0	128 0	325 9	769 24

TABLE II-2.—1980 STOL DEMAND—Concluded (MATRIX 4)

19	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
20	2448	6[illegible]3	952	282	558	184	123	39	236	23	132	26	196	320	347
	413	274	247	0	0	110	66	0	274	0	63	0	0	150	140
	8172														
21	5[illegible]1	1[illegible]	251	38	171	46	73	12	51	4	23	2	15	47	119
	326	49[illegible]	273	0	115	0	105	0	69	0	12	0	0	72	27
	2492														
22	556	150	217	61	93	78	27	8	24	1	13	0	45	75	134
	231	106	9	0	16	105	0	0	0	0	136	0	0	46	189
	2414														
23	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	672	221	256	50	101	41	15	2	12	0	4	0	28	22	85
	[illegible]	524	193	0	224	69	0	0	0	0	152	0	0	53	325
	[illegible]														
25	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	6[illegible]2	269	194	54	79	24	3	0	0	0	0	0	1	0	10
	40	125	62	0	68	12	235	0	152	0	0	0	0	74	336
	2331														
27	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0		0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	1568	651	516	194	269	112	83	15	13	0	3	0	9	8	23
	73	95	9	0	150	32	46	0	53	0	74	0	0	0	0
	4398														
30	1515	785	544	311	732	478	249	52	74	0	15	0	17	34	206
	310	216	24	0	140	27	193	0	325	0	376	0	0	0	0
	6597														

TABLE II-3.—1980 VTOL DEMAND (MATRIX 1)

USE FOLLOWING FORMAT TO READ THE DEMAND MATRIX BELOW FOR THE STOL PORTS.

DEMAND FROM STOL PORT TO ------------------------------ TO STOL PORTS ------------------------------ TOTAL DEMAND FROM STOL PORT

THE FOLLOWING IS THE DEMAND MATRIX WITH MODE SPLIT.

1	0 / 233	0 / 414	0 / 152	24 / 80	207 / 162	243 / 14	274 / 40	70 / 0	89 / 13	9 / 0	11 / 4	1 / 0	31 / 0	82 / 37	234 / 120	2544
2	0 / 319	0 / 513	0 / 205	3 / 84	195 / 149	401 / 10	561 / 57	123 / 0	155 / 25	20 / 0	33 / 22	2 / 0	22 / 0	75 / 73	273 / 254	3574
3	0 / 421	0 / 701	0 / 288	3 / 143	287 / 257	465 / 22	655 / 69	147 / 0	221 / 21	30 / 0	47 / 14	1 / 0	51 / 0	145 / 72	412 / 256	4737
4	139 / 462	2 / 679	6 / 279	0 / 140	85 / 165	424 / 11	779 / 45	180 / 0	301 / 8	48 / 0	80 / 6	3 / 0	39 / 0	108 / 35	337 / 159	4451
5	632 / 245	66 / 599	252 / 244	35 / 152	0 / 143	196 / 7	791 / 24	219 / 0	580 / 5	105 / 0	203 / 4	7 / 0	26 / 0	97 / 21	214 / 153	4959
6	1879 / 164	167 / 374	743 / 151	193 / 74	256 / 38	0 / 2	138 / 8	66 / 0	417 / 2	181 / 0	293 / 1	30 / 0	34 / 0	97 / 4	207 / 85	5516
7	1662 / 77	175 / 125	669 / 34	259 / 12	792 / 8	236 / 0	0 / 2	1 / 0	100 / 0	54 / 0	118 / 0	31 / 0	6 / 0	5 / 1	44 / 15	4325
8	714 / 121	79 / 118	369 / 28	161 / 11	339 / 7	186 / 2	2 / 3	0 / 0	79 / 0	49 / 0	101 / 0	34 / 0	11 / 0	21 / 0	150 / 9	2672
9	744 / 371	76 / 413	543 / 104	211 / 33	729 / 52	599 / 3	140 / 6	46 / 0	0 / 1	17 / 0	0 / 0	37 / 0	39 / 0	118 / 1	408 / 8	4742
10	318 / 147	79 / 192	205 / 52	93 / 22	378 / 21	639 / 2	270 / 3	89 / 0	53 / 0	0 / 0	40 / 0	8 / 0	30 / 0	159 / 1	282 / 6	3139
11	255 / 325	28 / 326	194 / 86	90 / 29	438 / 47	671 / 3	426 / 7	121 / 0	0 / 1	29 / 0	0 / 0	17 / 0	38 / 0	190 / 1	465 / 3	3942
12	134 / 165	19 / 162	88 / 52	33 / 18	211 / 20	479 / 1	815 / 3	327 / 0	745 / 0	52 / 0	227 / 0	0 / 0	35 / 0	335 / 0	246 / 0	4133
13	448 / 246	49 / 517	268 / 152	81 / 74	134 / 105	156 / 6	70 / 34	32 / 0	145 / 8	33 / 0	72 / 0	7 / 0	0 / 0	12 / 2	128 / 8	2328
14	816 / 526	95 / 970	476 / 332	141 / 159	274 / 144	284 / 13	26 / 25	32 / 0	308 / 5	130 / 0	240 / 0	57 / 0	7 / 0	0 / 2	130 / 12	5213
15	1659 / 82	246 / 664	962 / 306	339 / 310	438 / 47	407 / 21	136 / 63	176 / 0	650 / 12	145 / 0	388 / 2	34 / 0	47 / 0	86 / 3	0 / 62	7343
16	987 / 0	157 / 4	523 / 17	204 / 119	290 / 56	189 / 27	153 / 60	98 / 0	343 / 20	58 / 0	167 / 3	9 / 0	52 / 0	185 / 3	34 / 55	

TABLE II-3.—1980 VTOL DEMAND—Continued
(MATRIX 1)

	3818														
17	1252	217	689	293	537	313	188	78	282	37	140	5	87	303	250
	8	0	0	99	198	68	93	0	48	0	3	0	0	7	70
	2261														
18	566	95	338	147	276	155	80	18	83	7	36	3	32	132	163
	71	0	0	3	32	23	32	0	25	0	5	0	0	2	25
	2341														
19	765	82	283	145	308	137	68	17	61	6	25	2	30	108	299
	270	274	12	0	74	48	29	0	34	0	6	0	0	1	11
	3142														
20	7386	277	1158	315	573	185	130	35	198	20	97	5	74	201	185
	273	1045	178	158	0	34	131	0	78	0	14	0	0	28	61
	7875														
21	461	49	217	41	79	35	26	8	35	4	15	1	7	27	73
	171	579	174	181	72	0	128	0	26	0	4	0	0	9	13
	2446														
22	810	111	414	109	156	59	41	11	39	4	17	1	41	41	154
	270	543	177	78	153	73	0	0	36	0	73	0	0	42	181
	3634														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	565	123	286	49	90	35	13	2	10	0	3	0	15	15	53
	181	459	210	134	174	31	35	0	0	0	46	0	0	18	201
	2787														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	525	156	312	51	71	22	3	0	0	0	0	0	1	0	7
	30	63	55	41	28	6	207	0	82	0	0	0	0	42	218
	1322														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	1200	341	806	182	236	95	75	14	15	0	2	0	6	5	20
	45	192	42	6	76	17	101	0	31	0	22	0	0	0	0
	2442														
30	1700	356	920	266	587	347	212	40	59	5	11	0	8	20	121
	198	273	89	13	63	10	153	0	90	0	59	0	0	0	0
	5016														

TABLE II-3.—1980 VTOL DEMAND—Continued
(MATRIX 2)

THE FOLLOWING IS THE DEMAND MATRIX WITHOUT MODE SPLIT.

1	154544	22854	112459	21200	9482	2722	961	281	267	29	29	2	205	293	1591
	1312	11349	3496	1773	904	51	355	0	60	0	13	0	0	303	2995
	152570														
2	86126	135727	126428	57900	22531	5669	2268	566	493	69	90	4	156	243	1703
	3402	9438	2083	1540	715	40	373	0	154	0	85	0	0	928	15005
	474786														
3	211886	94336	264221	70916	29327	7567	2682	684	710	112	132	2	358	539	3413
	6487	20212	5850	2854	1427	84	553	0	106	0	45	0	0	640	7719
	731792														
4	84950	43655	117518	155077	74707	13052	4045	1008	1057	192	239	9	253	499	2795
	5345	12861	3323	1608	800	44	292	0	45	0	19	0	0	257	2469
	522799														
5	38084	13702	40557	68630	173445	93085	11438	2862	2902	735	817	34	277	853	3223
	3851	8671	2167	1125	641	25	170	0	26	0	11	0	0	151	1415
	464078														
6	20456	3113	14114	13026	97418	375604	82756	12657	9983	2300	2969	198	450	2938	5654
	2374	3343	886	431	215	10	55	0	9	0	4	0	0	29	459
	664121														
7	5423	571	2687	1479	9513	64386	203298	43294	28609	4103	4873	232	311	3925	2726
	969	850	172	64	60	2	9	0	1	0	0	0	0	4	51
	377712														
8	2751	374	1875	1040	5394	31068	113406	151548	63721	18515	12453	592	353	2916	1417
	544	464	93	37	45	7	11	0	0	0	0	0	0	2	27
	413658														
9	2723	245	1864	793	3769	15304	71793	95604	432439	65543	110935	2882	1766	17197	5573
	2109	1818	405	130	275	15	35	0	2	0	0	0	0	5	24
	830475														
10	1184	172	785	398	2435	9307	29438	41243	145343	172573	66365	13221	659	4922	2287
	528	724	180	74	94	8	16	0	0	0	0	0	0	3	17
	492046														
11	766	74	553	274	1652	5853	21341	19160	166948	46055	233693	9361	1313	10946	3770
	1480	1452	292	96	217	15	29	0	3	0	0	0	0	3	8
	525134														
12	345	47	228	132	725	2478	9563	5247	27343	25976	41088	103816	401	2634	1230
	545	469	144	48	65	3	11	0	0	0	0	0	0	0	0
	221462														
13	2781	322	1793	561	1054	1529	2353	1062	4517	630	2222	116	85559	9724	27876
	10122	9986	2752	1049	22115	1641	1389	0	166	0	6	0	0	20	45
	190878														
14	2758	349	1927	641	1958	6122	15262	5286	25299	2495	11618	519	7815	155205	53379
	11659	8283	2643	902	1209	82	275	0	22	0	1	0	0	7	38
	315089														
15	11155	1524	8174	2719	5577	9135	9215	2014	7751	1164	3290	197	13603	44560	308962
	114357	52191	10448	4151	4521	273	971	0	86	0	8	0	0	20	271
	705948														
16	14318	1617	9647	7314	3637	2285	6670	444	1929	263	812	35	3054	5313	75957
	245112	156198	24203	8292	5464	306	1390	0	147	0	11	0	0	40	405
	[illegible]														
17	97374	4112	20844	5773	6696	2516	1794	373	1250	152	560	17	2769	3132	26785
	142111	965175	117591	27544	25786	894	4129	0	460	0	23	0	0	114	952
	[illegible]														
18	17645	1632	7415	1975	2177	779	397	65	291	24	120	8	765	839	5531
	[illegible]	114990	187966	66451	5800	326	6636	0	540	0	27	0	0	136	715
	[illegible]														

TABLE II-3.—1980 VTOL DEMAND—Continued
(MATRIX 2)

19	11351	1303	5971	1462	1755	635	332	57	213	28	81	7	515	617	3775
	12131	56241	69312	167476	4689	534	16583	0	1198	0	67	0	0	290	1241
	346706														
20	13317	1411	6898	1616	2324	904	830	235	1050	93	462	23	22940	1854	9965
	16865	76359	15271	1101	288959	28698	33684	0	2681	0	128	0	0	361	410
	535679														
21	1751	156	860	169	273	145	180	63	222	21	96	4	3682	306	1372
	1891	5773	3170	2054	38211	72319	7474	0	18652	0	115	0	0	178	127
	159292														
22	5956	652	2753	625	755	258	261	46	170	17	67	4	1401	347	2315
	4578	15685	13367	29003	32469	3625	154131	0	23030	0	1022	0	0	2520	2199
	256170														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	2957	593	1632	271	378	124	49	6	34	1	12	0	422	77	450
	1415	4773	3815	5614	6619	14363	42018	0	177527	0	15851	0	0	6634	4736
	751545														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	1718	629	1754	173	159	58	7	0	0	0	0	0	12	1	34
	112	333	272	433	250	82	2532	0	13712	0	232556	0	0	21012	3782
	278955														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	4213	3910	6160	1249	1214	384	231	40	49	1	5	0	55	21	130
	464	1271	580	1634	881	172	6533	0	5833	0	12071	0	0	77232	54581
	183377														
30	34416	26574	29707	5719	5117	1770	773	132	173	12	30	1	47	74	637
	1655	4676	3617	3743	550	73	2790	0	2239	0	1549	0	0	32690	171341
	325013														

TABLE II-3.—1980 VTOL DEMAND—*Continued* (MATRIX 3)

THE FOLLOWING IS A BALANCED DEMAND MATRIX WITHOUT MODE SPLIT.

1	0	109980	323815	106090	47576	23218	6384	3072	2590	1213	795	337	2986	3089	12786
	17620	44683	17141	13164	14221	1842	5651	0	2913	0	1731	0	0	8516	37411
	808824														
2	109980	0	220764	101755	35233	8782	2799	945	738	201	164	51	478	642	3227
	5219	13550	4716	2843	2126	196	1065	0	977	0	714	0	0	4828	41539
	563532														
3	323815	220764	0	184434	69884	21681	5369	2559	2564	897	685	230	2151	2526	11587
	16534	40956	13255	8785	8325	944	3253	0	1738	0	1099	0	0	6740	37426
	988161														
4	106090	101755	184434	0	143337	23078	5524	2048	1847	590	513	111	854	1140	5505
	8395	18634	5198	3079	2416	213	917	0	317	0	189	0	0	1505	9138
	625872														
5	47576	35233	69884	143337	0	187493	20941	9256	6671	3170	2469	759	1331	2811	3800
	7688	15367	4204	2881	2965	298	925	0	404	0	210	0	0	1365	6522
	581560														
6	23218	8782	21681	23078	187493	0	147142	43725	25287	12307	8822	2676	1979	9060	14789
	4610	5659	1665	1066	1119	155	313	0	133	0	62	0	0	413	2229
	547663														
7	6384	2799	5369	5524	20941	147142	0	156700	100192	33541	26254	8895	2664	19087	11941
	3039	2244	569	396	890	182	210	0	50	0	7	0	0	235	829
	556084														
8	3072	945	2559	2048	9256	43725	156700	0	184325	59758	31613	5839	1415	8202	3431
	1028	797	198	94	280	70	57	0	6	0	0	0	0	42	159
	514579														
9	2590	738	2564	1847	6671	25287	100192	184325	0	214636	277883	30225	6283	42496	13324
	3938	3068	696	343	1275	237	205	0	36	0	0	0	0	54	202
	919115														
10	1213	201	897	590	3170	12307	33541	59758	214636	0	112420	39097	1289	7917	3451
	1221	876	204	94	187	29	33	0	1	0	0	0	0	4	29
	493115														
11	795	164	685	513	2469	8822	26254	31613	277883	112420	0	50449	3535	22564	7060
	2292	1812	412	177	679	111	96	0	15	0	0	0	0	8	38
	550866														
12	337	51	230	111	759	2676	8895	5839	30225	39097	50449	0	517	3153	1427
	584	496	152	55	88	7	15	0	0	0	0	0	0	0	1
	145164														
13	2986	478	2151	854	1331	1979	2664	1415	6283	1289	3535	517	0	17539	41479
	13176	12755	3557	1564	45063	4723	2790	0	538	0	18	0	0	75	92
	168851														
14	3089	642	2526	1140	2811	9060	19087	8202	42496	7917	22564	3153	17539	0	97939
	17012	11415	2879	1519	3063	362	582	0	99	0	2	0	0	28	112
	275258														
15	12786	3227	11587	5505	3800	14789	11941	3431	13324	3451	7060	1427	41479	97939	0
	189814	78976	15979	7926	14486	1649	2986	0	536	0	42	0	0	150	908
	550154														
16	17620	5219	16534	8395	7688	4610	3039	1028	3938	1221	2292	584	13176	17012	189814
	0	308259	44453	20383	22329	2197	5918	0	1562	0	123	0	0	448	2064
	659860														
17	44683	13550	40956	18634	15367	5659	2244	797	3068	876	1812	496	12755	11415	78976
	308259	0	232541	77735	102125	6667	19814	0	5230	0	353	0	0	1335	5618
	1311145														
18	17141	4716	13255	5198	4204	1665	569	198	696	204	412	152	3557	2879	15979
	44453	232541	0	134753	29071	2496	13403	0	4395	0	299	0	0	1116	3332
	678564														

TABLE II-3.—1980 VTOL DEMAND—Continued (MATRIX 3)

19	13164	2843	8785	3070	2881	1066	396	94	343	94	177	55	1564	1519	7926
	20383	77785	134753	0	13590	2592	45583	0	6886	0	500	0	0	1894	4989
	352932														
20	14221	2126	8325	2416	2965	1119	690	280	1275	187	679	88	45053	3063	14486
	22329	102125	25071	13590	0	66889	65553	0	9300	0	378	0	0	1212	910
	404536														
21	1842	196	944	213	298	155	182	70	237	29	111	7	4723	382	1645
	2157	6667	2456	2592	66849	0	11099	0	33021	0	197	0	0	350	200
	136742														
22	5651	1065	3253	917	925	313	210	57	235	33	96	15	2790	582	2986
	5918	19614	19403	45583	65553	11099	0	0	65048	0	3554	0	0	9053	4979
	269102														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	2913	577	1738	317	414	133	50	6	36	1	15	0	588	39	536
	1562	5230	4395	6886	9300	33021	65048	0	0	0	29563	0	0	12437	6974
	162229														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	1731	714	1259	139	210	62	7	0	0	0	0	0	18	2	42
	173	353	299	500	378	197	3554	0	29563	0	0	0	0	33083	5331
	77456														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	8516	4628	6740	1505	1365	413	235	42	54	4	8	0	75	28	150
	448	1335	1116	1894	1212	350	9053	0	12437	0	33083	0	0	0	87271
	172162														
30	37411	41539	37426	8189	6522	2229	829	159	202	29	38	1	92	112	908
	2364	5613	3332	4989	910	200	4979	0	6974	0	5331	0	0	87271	0
	257353														

TABLE II-3.—1980 VTOL DEMAND—Continued
(MATRIX 4)

THE FOLLOWING IS A BALANCED DEMAND MATRIX WITH MODE SPLIT.

1	0	0	0	152	819	2078	1876	783	878	377	306	135	479	898	1932
	1220	1646	749	784	2548	496	850	0	568	0	529	0	0	1238	1339
	22699														
2	0	0	0	5	261	568	696	202	231	59	61	20	71	170	518
	476	731	300	172	426	50	168	0	148	0	178	0	0	414	610
	6534														
3	0	0	0	9	539	1207	1323	536	770	236	241	89	320	621	1374
	545	1390	627	531	1455	239	483	0	306	0	326	0	0	878	1076
	15522														
4	152	5	9	0	120	617	1037	341	512	141	170	42	120	250	646
	617	569	426	285	480	52	154	0	57	0	58	0	0	217	425
	7491														
5	819	261	539	120	0	452	1583	618	1309	483	641	208	161	371	652
	537	1136	520	459	676	86	180	0	96	0	75	0	0	256	740
	12974														
6	2078	568	1207	617	452	0	374	252	1016	820	965	509	190	351	615
	353	691	307	211	213	38	67	0	37	0	23	0	0	99	432
	12515														
7	1876	696	1323	1037	1583	374	0	3	240	324	545	846	76	31	180
	230	313	114	83	138	26	42	0	13	0	3	0	0	77	227
	10397														
8	783	202	536	341	618	252	3	0	125	138	222	362	42	53	326
	220	156	46	28	42	10	14	0	2	0	0	0	0	14	48
	4623														
9	878	231	770	512	1309	1016	240	125	0	70	0	782	185	426	1059
	713	684	187	34	251	39	45	0	11	0	0	0	0	17	67
	9709														
10	377	59	236	141	483	820	324	138	70	0	69	60	64	239	427
	256	219	59	28	40	5	8	0	0	0	0	0	0	1	11
	4184														
11	306	61	241	170	641	965	545	222	0	69	0	244	110	429	853
	493	476	122	55	143	18	23	0	4	0	0	0	0	3	14
	6207														
12	135	20	89	42	208	509	846	362	782	60	244	0	42	362	280
	174	167	55	20	25	1	4	0	0	0	0	0	0	0	0
	4429														
13	479	71	320	120	161	190	76	42	185	64	110	42	0	19	175
	379	603	184	103	179	13	75	0	23	0	1	0	0	8	15
	3597														
14	898	170	621	250	371	351	31	53	426	239	429	362	19	0	216
	711	1374	463	267	355	40	67	0	20	0	0	0	0	7	22
	7748														
15	1932	518	1374	646	652	615	180	326	1059	427	853	280	175	216	0
	116	514	469	609	282	94	216	0	71	0	9	0	0	23	183
	17338														
16	1220	476	345	697	537	353	230	220	713	256	492	174	339	711	116
	0	12	43	389	331	198	330	0	201	0	33	0	0	52	254
	9236														
17	1646	731	1390	569	1136	691	313	136	684	219	476	167	603	1274	914
	12	1	0	372	1243	647	636	0	547	0	66	0	0	109	340
	15401														
18	748	300	627	426	520	307	114	46	187	59	122	55	184	463	469
	44	0	0	15	211	197	210	0	235	0	60	0	0	44	114
	5761														

TABLE II-3.–1980 VTOL DEMAND–Concluded
(MATRIX 4)

19	784 389 5325	172 272	531 15	285 0	459 233	211 230	80 107	28 0	94 173	29 0	55 48	20 0	103 0	267 7	609 24
20	2548 331 11191	426 1243	1455 211	490 233	676 0	223 106	138 284	42 0	251 252	40 0	143 42	25 0	179 0	355 104	282 124
21	496 158 2859	50 647	239 197	52 230	86 106	38 0	26 201	10 0	38 57	5 0	18 9	1 0	13 0	40 26	94 23
22	850 330 4950	169 676	483 210	154 107	180 284	67 201	42 0	14 0	45 70	8 0	23 280	4 0	75 0	67 142	216 334
23	0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
24	568 201 3359	148 547	306 235	57 173	96 252	37 57	13 70	2 0	11 0	0 0	4 128	0 0	23 0	20 49	71 291
25	0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
26	529 33 2219	178 66	326 60	59 48	75 42	23 9	3 280	0 0	0 120	0 0	0 0	0 0	1 0	0 64	9 277
27	0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
28	0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
29	1236 52 3848	414 109	878 44	217 7	256 104	59 26	77 142	14 0	17 49	1 0	3 64	0 0	8 0	7 0	23 0
30	1339 254 7081	610 340	1076 114	425 24	740 124	432 23	227 334	48 0	67 291	11 0	14 277	0 0	15 0	32 0	183 0

TABLE II-4.—1990 STOL DEMAND (MATRIX 1)

USE FOLLOWING FORMAT TO READ THE DEMAND MATRIX BELOW FOR THE STOL PORTS.

DEMAND FROM STOL PORT TO ------------------------------ TO STOL PORTS ------------------------------ TOTAL DEMAND FROM STOL PORT

THE FOLLOWING IS THE DEMAND MATRIX WITH MODE SPLIT.

1	0	0	0	2	223	423	407	135	244	19	73	2	55	132	313
	350	264	134	43	183	30	40	0	27	0	16	0	0	90	263
	3526														
2	0	0	0	0	176	576	586	183	311	20	80	5	45	132	425
	476	424	152	36	188	25	55	0	37	0	28	0	0	118	321
	4399														
3	0	0	0	0	37	214	507	116	279	28	97	3	48	129	260
	171	164	112	33	129	24	31	0	19	0	6	0	0	49	136
	2592														
4	4	0	0	0	14	333	692	152	297	25	93	5	34	96	250
	338	320	129	21	99	14	24	0	10	0	8	0	0	44	145
	3185														
5	628	97	111	15	0	118	321	248	790	77	308	14	49	164	235
	276	414	190	17	121	14	14	0	5	0	4	0	0	36	265
	4493														
6	2536	348	656	166	144	0	0	81	539	134	407	58	68	170	277
	292	410	123	5	37	6	7	0	3	0	1	0	0	14	162
	6646														
7	2816	326	825	242	931	1	0	2	129	46	167	54	26	10	66
	155	139	27	1	11	3	2	0	0	0	0	0	0	1	53
	6034														
8	1256	201	563	153	515	260	4	0	99	50	141	71	45	51	298
	307	167	21	2	13	5	2	0	0	0	0	0	0	2	21
	4246														
9	2060	326	1411	259	1313	1043	217	58	0	83	0	65	105	168	755
	775	470	71	9	64	20	5	0	2	0	0	0	0	2	26
	9259														
10	375	76	192	56	316	533	220	74	177	0	73	19	34	134	232
	202	147	25	4	12	6	1	0	0	0	0	0	0	1	12
	2921														
11	667	131	505	121	713	1106	681	177	0	60	0	25	87	285	715
	591	368	48	7	45	15	3	0	2	0	0	0	0	1	13
	6367														
12	362	79	231	47	329	862	1309	608	1105	99	335	0	77	488	354
	292	209	27	2	24	9	0	0	0	0	0	0	0	0	2
	6392														
13	686	142	393	77	230	337	241	124	336	38	157	19	0	32	224
	516	480	136	85	99	31	26	0	12	0	1	0	0	2	19
	4444														
14	1095	240	587	137	429	530	62	72	372	101	312	90	17	0	150
	866	900	227	45	137	53	14	0	6	0	0	0	0	3	28
	6514														
15	2305	553	937	294	502	548	214	314	828	103	524	54	72	119	0
	167	557	456	89	130	53	46	0	21	0	3	0	0	7	140
	9033														
16	1274	350	468	205	353	368	316	219	549	50	288	15	96	325	69
	0	21	193	80	111	80	55	0	47	0	4	0	0	11	115

TABLE II-4.—1990 STOL DEMAND—Continued (MATRIX 1)

	5624															
17	911	270	355	183	454	395	231	91	240	17	131	6	83	303	280
	30	0	6	34	60	85	24	0	73	0	7	0	0	9	67
	4345														
18	1012	224	451	148	385	234	161	29	79	6	37	3	54	152	429
	384	17	0	49	93	68	5	0	54	0	8	0	0	2	17
	4101														
19	497	105	233	45	90	39	50	13	36	2	15	1	86	70	194
	292	177	112	0	0	110	11	0	63	0	19	0	0	38	63
	2359														
20	2951	637	1188	246	552	234	199	57	215	12	107	9	90	235	328
	546	365	273	0	0	49	57	0	119	0	20	0	0	54	111
	8654														
21	916	158	386	53	144	99	127	44	154	8	65	5	33	154	229
	540	799	303	200	69	0	92	0	43	0	6	0	0	15	24
	4666														
22	691	155	287	60	105	53	40	9	27	1	12	0	26	25	109
	214	98	7	5	25	40	0	0	0	0	63	0	0	10	114
	2180														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	1117	285	447	71	152	79	43	11	17	0	8	0	27	27	114
	402	714	250	117	202	54	0	0	0	0	78	0	0	28	279
	4523														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	1334	428	460	87	138	54	21	2	0	0	0	0	2	1	19
	75	198	79	60	56	13	254	0	160	0	0	0	0	71	374
	3888														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	2917	863	978	251	400	210	170	30	45	3	10	0	9	14	51
	133	136	10	99	127	27	55	0	46	0	38	0	0	0	0
	6624														
30	2141	585	753	246	729	585	414	73	113	7	29	1	14	44	285
	409	229	19	52	92	14	99	0	118	0	76	0	0	0	0
	7126														

TABLE II-4.—1990 STOL DEMAND—Continued
(MATRIX 2)

THE FOLLOWING IS THE DEMAND MATRIX WITHOUT MODE SPLIT.

1	272979	108728	103459	21179	16873	4629	1865	507	680	63	187	4	332	452	2378
	8530	17376	3059	160	1354	124	199	0	121	0	50	0	0	808	8848
	574944														
2	207424	250300	122223	78330	32921	8124	3267	792	944	76	214	12	320	511	2734
	9070	16756	2974	130	1239	115	265	0	210	0	105	0	0	1429	20388
	760853														
3	118829	64522	141250	45265	39327	7978	2809	701	984	127	292	9	436	704	4278
	22804	32448	3365	150	1441	127	178	0	94	0	18	0	0	381	3432
	491949														
4	69876	74396	89304	124277	70858	10643	3435	841	998	112	265	13	242	437	2151
	6472	9041	1484	68	629	58	95	0	46	0	23	0	0	344	3122
	469240														
5	51073	25217	60193	65158	236339	107082	14057	3443	3705	616	1111	56	459	1393	4131
	7555	9609	1530	56	823	62	62	0	26	0	13	0	0	267	2191
	516233														
6	26502	6207	17719	7991	116642	435539	96022	17413	13324	2616	3871	327	803	4763	7149
	4249	3929	612	15	315	[illegible]	23	0	11	0	4	0	0	68	789
	767005														
7	9032	1242	3767	1208	11796	78529	244020	55287	38600	3467	6472	468	763	7052	3762
	1809	1127	124	4	134	18	6	0	1	0	1	0	0	4	166
	468859														
8	4487	866	2776	902	6725	40704	143017	178934	109409	15220	15340	1017	877	6587	2652
	1291	731	65	5	121	20	5	0	1	0	0	0	0	6	60
	531818														
9	5714	983	4622	899	6210	25393	104347	131699	646770	82837	171406	6170	3353	28064	8976
	4124	2507	248	26	433	103	14	0	7	0	1	0	0	7	70
	1235043														
10	1227	283	838	261	2305	8903	24975	33432	127944	103988	53820	7119	768	4466	2178
	1036	546	70	11	88	26	3	0	0	0	0	0	0	4	32
	374323														
11	1696	345	1431	345	2431	8505	27928	23728	220456	35200	286458	14133	2054	15377	5223
	2414	1500	142	19	285	68	8	0	4	0	0	0	0	4	34
	643788														
12	906	199	591	120	1049	3870	10998	7623	39870	15710	55381	155044	660	3656	1714
	869	611	70	6	90	29	0	0	0	0	0	0	0	0	5
	299071														
13	3898	891	2815	487	1633	2903	5656	2567	7559	661	3562	205	110308	16149	39853
	17433	13134	2011	1012	29125	2714	390	0	219	0	13	0	0	23	166
	264297														
14	3582	884	2766	586	2991	10270	28094	11059	33930	2325	15190	715	11672	205544	68380
	16520	8888	1124	145	1609	363	50	0	27	0	1	0	0	12	90
	426617														
15	14038	3510	12607	2142	6924	11853	13116	3337	9541	913	4124	268	18477	56278	475878
	149292	50665	5020	537	6164	711	299	0	119	0	11	0	0	48	574
	846446														
16	31060	7639	36048	3991	7785	4355	3847	995	2779	255	1248	54	5984	7745	100757
	438553	316651	20859	1554	26299	1457	918	0	429	0	29	0	0	154	1431
	1121206														
17	41047	9874	37137	3955	6590	2759	1608	305	1102	60	527	18	3091	2881	22202
	221661	683241	115591	2294	24978	1734	2433	0	1256	0	52	0	0	338	2223
	1195097														
18	10985	3820	10006	1463	2420	938	546	94	270	18	115	8	1110	805	4915
	29272	147141	234918	5634	11748	1401	7334	0	2739	0	174	0	0	528	2017
	491505														

TABLE II-4—1990 STOL DEMAND—Continued
(MATRIX 2)

19	1825	386	1028	147	279	107	129	35	99	4	40	3	1120	232	1173
	4078	8269	8508	5827	28016	3086	17877	0	4470	0	230	0	0	493	418
	87879														
20	18117	3835	10533	1438	3108	1423	1537	452	1357	79	623	36	32385	2737	15054
	64685	102223	20578	30942	325493	68535	7024	0	3995	0	195	0	0	485	778
	717597														
21	3584	684	1941	231	572	397	785	299	900	49	398	26	7220	1500	3817
	7660	13980	4390	5659	80228	113900	2758	0	18597	0	137	0	0	210	161
	270083														
22	3496	812	1681	258	422	172	145	27	84	5	34	1	552	115	858
	3478	10483	14151	20990	7783	1737	133869	0	28593	0	1273	0	0	2811	2236
	236066														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	5409	1674	2340	360	624	261	143	34	56	0	27	0	589	123	655
	3502	10551	10554	8883	8488	25909	48138	0	249970	0	24938	0	0	11341	6178
	420847														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	4058	1511	1448	273	393	138	53	6	1	0	0	0	25	4	70
	320	869	850	487	403	178	2937	0	21934	0	308183	0	0	28935	6064
	379160														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	20259	8556	6495	1831	2183	763	495	82	131	9	28	0	80	50	282
	1329	3157	2624	1116	1084	282	7376	0	9126	0	14050	0	0	114774	87765
	283967														
30	71403	43339	22494	7046	7386	2803	1422	229	329	18	77	3	111	159	1329
	4780	9900	5042	417	611	112	2530	0	2614	0	1990	0	0	44927	209536
	440707														

TABLE II-4.—1990 STOL DEMAND—Continued
(MATRIX 3)

THE FOLLOWING IS A BALENCED DEMAND MATRIX WITHOUT MODE SPLIT.

1	0	316152	222288	91055	67946	31131	10897	4994	6394	1290	1883	910	4230	4034	16416
	39590	58423	20045	1985	19471	3708	3695	0	5590	0	4108	0	0	21107	80251
	1037593														
2	316152	0	186745	152726	58138	14411	4509	1658	1927	359	559	211	1211	1395	6244
	16709	26630	6794	516	5074	799	1077	0	1884	0	1616	0	0	9985	63767
	881036														
3	222288	186745	0	134569	99520	25697	6576	3477	5606	965	1723	600	3251	3470	16885
	58852	69635	13371	1178	11974	2068	1859	0	2434	0	1466	0	0	6876	25936
	907011														
4	91055	152726	134569	0	136016	18634	4643	1743	1897	373	610	133	729	1023	4303
	10463	13066	2952	215	2067	289	353	0	405	0	296	0	0	2175	10168
	596844														
5	67946	58138	99520	136016	0	223724	25853	10168	9915	2921	3542	1105	2092	4384	11055
	15340	16199	3950	335	3937	634	484	0	650	0	406	0	0	2450	9517
	716341														
6	31131	14411	25697	18634	223724	0	174551	58117	38717	11519	12376	4197	3706	15033	19002
	8604	6668	1610	122	1738	419	195	0	272	0	142	0	0	831	3532
	675028														
7	10897	4509	6576	4643	25853	174551	0	198304	142947	28442	34400	11466	6419	35146	16878
	5656	2735	670	133	1671	803	151	0	144	0	54	0	0	499	1588
	715135														
8	4994	1658	3477	1743	10168	58117	198304	0	241108	48652	39068	8640	3464	17646	5989
	2206	1116	159	40	573	319	32	0	35	0	6	0	0	88	1289
	647971														
9	6394	1927	5606	1897	9915	38717	142947	241108	0	210781	391862	46040	10912	61994	18517
	6903	3609	518	125	1850	1003	98	0	63	0	2	0	0	138	359
	1203325														
10	1290	359	965	373	2921	11519	28442	48652	210781	0	89020	22829	1429	6791	3091
	1291	606	88	15	167	75	8	0	0	0	0	0	0	13	50
	430775														
11	1883	559	1723	610	3542	12376	34400	39068	391862	89020	0	69514	5616	30567	9347
	3662	2027	257	59	908	466	42	0	31	0	0	0	0	32	111
	697682														
12	910	211	600	133	1105	4197	11466	8640	46040	22829	69514	0	865	4371	1982
	923	629	78	9	126	55	1	0	0	0	0	0	0	0	8
	174692														
13	4230	1211	3251	729	2092	3706	6419	3464	10912	1429	5616	865	0	27821	57280
	23417	16225	3121	2132	61510	9934	942	0	808	0	38	0	0	103	217
	247472														
14	4034	1395	3470	1023	4334	15033	35146	17646	61994	6791	30567	4371	27821	0	124658
	24265	11769	1929	377	4346	1863	165	0	150	0	5	0	0	62	249
	383513														
15	16416	6244	16885	4303	11055	19002	16878	5989	18517	3091	9347	1982	57280	124658	0
	290049	72867	1935	1710	21168	4528	1157	0	814	0	81	0	0	330	1903
	676189														
16	39590	16709	54852	10463	15340	8604	5656	2286	6903	1291	3662	923	23417	24265	250049
	0	538312	50131	5632	90984	9117	4396	0	3931	0	349	0	0	1483	6251
	1173546														
17	58423	20630	63635	13006	16193	6638	2735	1116	3609	606	2027	629	16225	11769	72867
	538312	0	262732	10563	127201	15714	12916	0	11807	0	921	0	0	3495	12133
	1297948														
18	20045	6794	13371	2952	3950	1610	670	159	518	88	257	78	3121	1929	9915
	50131	262732	0	14142	32326	5791	21485	0	13293	0	1024	0	0	3152	7079
	476632														

TABLE II-4.—1990 STOL DEMAND—Continued
(MATRIX 3)

19	1985	516	1178	215	335	122	133	40	125	15	59	9	2132	377	1710
	5632	10563	14142	0	58958	8745	38867	0	13353	0	717	0	0	1609	835
	162372														
20	19471	5074	11974	2067	3937	1738	1671	573	1850	167	908	126	61510	4346	21168
	90984	127201	32326	58958	0	148763	14807	0	12483	0	598	0	0	1569	1589
	625858														
21	3708	799	2068	289	634	419	803	319	1003	75	466	55	9934	1863	4528
	9117	15714	5791	8745	148763	0	4495	0	44506	0	315	0	0	492	273
	265174														
22	3695	1077	1859	353	484	195	151	32	98	8	42	1	942	165	1157
	4396	12916	21485	38867	14807	4495	0	0	76731	0	4210	0	0	10187	4766
	203119														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	5593	1884	2434	406	650	272	144	35	63	0	31	0	808	150	814
	3931	11807	13293	13353	12483	44506	76731	0	0	0	46872	0	0	20467	8792
	265516														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	4108	1616	1466	296	406	142	54	6	2	0	0	0	38	5	61
	349	921	1024	717	598	315	4210	0	46872	0	0	0	0	42985	7974
	114185														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	21107	9985	6876	2175	2450	831	499	88	138	13	32	0	103	62	330
	1483	3495	3152	1609	1563	492	10187	0	20467	0	42985	0	0	0	132692
	262820														
30	80251	63707	25926	10168	9577	3592	1588	289	399	50	111	8	217	249	1963
	6201	12123	7079	835	1589	273	4766	0	8792	0	7974	0	0	132692	0
	380359														

TABLE II-4.—1990 STOL DEMAND— Continued
(MATRIX 4)

THE FOLLOWING IS A BALANCED DEMAND MATRIX WITH MODE SPLIT.

1	0	0	0	6	851	2959	3223	1391	2303	394	740	364	741	1226	2678
	1623	1175	1146	540	3135	946	731	0	1144	0	1350	0	0	3007	2403
	34078														
2	0	0	0	0	273	924	912	383	637	96	211	84	187	373	978
	826	694	376	141	825	184	210	0	322	0	456	0	0	981	907
	10978														
3	0	0	0	0	143	869	1332	679	1690	220	601	235	441	716	1196
	579	520	562	266	1317	411	318	0	466	0	466	0	0	1027	859
	14950														
4	6	0	0	0	29	439	934	304	555	82	214	52	111	234	583
	543	503	277	66	345	67	84	0	81	0	95	0	0	294	391
	6350														
5	851	273	143	29	0	262	1252	763	2103	393	1021	343	279	593	757
	629	868	576	106	673	158	119	0	157	0	143	0	0	436	934
	13808														
6	2959	924	869	499	262	0	1	341	1582	668	1513	919	405	701	825
	660	805	357	43	271	105	60	0	82	0	55	0	0	224	746
	15876														
7	3223	912	1332	934	1252	1	0	5	346	266	848	1363	267	73	279
	473	370	188	51	210	130	42	0	43	0	22	0	0	172	437
	13269														
8	1391	383	679	304	763	341	5	0	157	125	318	680	169	123	612
	526	258	50	15	70	49	11	0	11	0	2	0	0	32	94
	7169														
9	2303	637	1690	555	2103	1582	346	157	0	260	0	1171	442	540	1533
	1324	710	150	46	279	174	32	0	20	0	1	0	0	47	139
	16241														
10	394	96	220	82	393	668	266	125	260	0	133	118	72	235	335
	253	164	31	5	24	14	3	0	0	0	0	0	0	5	18
	3912														
11	740	211	601	214	1021	1513	848	318	0	133	0	359	244	597	1239
	680	499	85	23	153	80	15	0	3	0	0	0	0	12	43
	9837														
12	364	84	235	52	343	919	1363	680	1171	118	359	0	96	578	447
	307	215	30	4	33	14	0	0	0	0	0	0	0	0	3
	7416														
13	741	187	441	111	279	405	267	169	442	72	244	96	0	49	295
	612	564	190	171	188	64	53	0	39	0	3	0	0	11	33
	5724														
14	1226	373	716	234	593	701	73	123	540	235	597	578	49	0	309
	1191	1203	379	114	372	207	39	0	33	0	1	0	0	17	73
	9977														
15	2678	978	1196	583	757	825	279	612	1533	335	1239	447	295	309	0
	237	837	885	283	453	262	156	0	135	0	22	0	0	58	425
	15844														
16	1623	826	579	543	629	660	473	526	1324	253	880	307	612	1191	237
	0	51	577	372	657	620	270	0	448	0	79	0	0	144	543
	14424														
17	1175	694	520	503	868	805	370	258	710	164	499	215	564	1203	837
	51	0	22	211	425	884	122	0	787	0	205	0	0	146	236
	12532														
18	1146	376	562	277	576	357	188	50	159	31	85	30	190	379	855
	577	22	0	161	366	371	12	0	304	0	87	0	0	12	36
	7229														

TABLE II-4.—1990 STOL DEMAND—Concluded
(MATRIX 4)

19	540	141	266	66	106	43	51	15	46	6	23	4	171	114	283
	372	211	161	0	0	310	16	0	180	0	79	0	0	138	114
	3455														
20	3135	825	1317	345	673	271	210	70	279	24	153	33	188	372	458
	657	425	366	0	0	118	81	0	321	0	76	0	0	181	203
	10781														
21	946	184	411	67	158	105	130	49	174	14	80	14	64	207	282
	620	884	371	310	118	0	133	0	97	0	19	0	0	42	19
	5518														
22	731	210	318	84	119	60	42	11	32	3	15	0	53	39	156
	270	122	12	16	81	133	0	0	0	0	318	0	0	64	213
	3103														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	1144	322	466	81	157	82	43	11	20	0	9	0	39	33	135
	448	787	304	180	321	97	0	0	0	0	238	0	0	74	357
	5388														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	1350	456	466	95	143	55	22	2	1	0	0	0	3	1	22
	79	205	87	79	76	19	318	0	238	0	0	0	0	109	451
	4276														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	3007	981	1027	294	436	224	172	32	47	5	12	0	11	17	58
	144	146	12	138	181	42	64	0	74	0	109	0	0	0	0
	7232														
30	2403	907	889	391	934	746	467	94	139	18	43	3	33	73	425
	543	296	36	114	203	39	213	0	397	0	451	0	0	0	0
	9857														

TABLE 11-5.—1990 HELICOPTER DEMAND (MATRIX 1)

USE FOLLOWING FORMAT TO READ THE DEMAND MATRIX BELOW FOR THE STOL PORTS.

DEMAND FROM STOL PORT TO ------------------------------ TO STOL PORTS ------------------------------ TOTAL DEMAND FROM STOL PORT

THE FOLLOWING IS THE DEMAND MATRIX WITH MODE SPLIT.

1	0 255 3185	0 442	0 184	32 105	221 186	293 19	357 53	91 0	156 17	26 0	50 10	1 0	39 0	95 64	262 228
2	0 351 4039	3 551	0 237	4 109	197 175	443 14	610 66	135 0	209 26	22 0	51 24	4 0	28 0	91 92	306 286
3	0 467 6731	0 759	0 349	4 193	302 295	555 28	832 90	185 0	335 33	57 0	109 15	3 0	66 0	168 99	466 320
4	168 468 5541	3 754	9 344	0 187	97 201	516 19	983 62	218 0	406 13	66 0	141 8	7 0	51 0	145 54	400 219
5	749 295 6274	95 686	355 288	56 186	0 173	258 11	990 33	257 0	682 5	127 0	276 4	12 0	44 0	163 36	272 221
6	2319 271 7405	235 495	1045 237	266 111	306 58	0 6	181 14	94 0	500 7	231 0	397 1	53 0	65 0	170 12	270 155
7	2540 121 6575	282 195	1111 67	396 24	999 19	321 3	0 3	3 0	134 0	73 0	162 0	50 0	25 0	12 1	61 51
8	1124 244 4318	177 227	673 65	242 19	518 19	269 5	6 4	0 0	108 0	69 0	140 0	65 0	42 0	51 2	286 20
9	1566 519 7907	169 542	1235 152	393 55	1025 85	911 16	224 8	63 0	0 2	29 0	0 0	61 0	88 0	166 1	573 21
10	657 368 4962	71 250	436 81	159 31	521 30	953 10	400 6	124 0	80 0	0 0	60 0	32 0	66 0	238 2	429 17
11	618 464 6257	73 469	504 132	202 44	650 64	1056 14	663 9	175 0	0 2	46 0	0 0	27 0	81 0	280 1	680 13
12	348 238 5717	43 212	237 78	77 26	300 29	807 8	1223 3	569 0	1076 0	184 0	358 0	0 0	69 0	458 0	370 2
13	611 418 4622	63 715	419 228	120 124	214 141	324 33	231 45	115 0	303 11	72 0	147 1	16 0	0 0	34 2	201 18
14	975 662 7097	143 1216	664 445	213 237	424 215	530 49	71 30	72 0	375 6	171 0	306 0	83 0	19 0	0 3	181 27
15	2072 124 9574	342 857	1307 430	420 406	534 145	537 49	199 77	239 0	742 19	189 0	497 2	49 0	65 0	114 6	0 132
16	1179 0	215 6	645 24	265 168	329 93	268 51	231 71	165 0	340 30	76 0	208 4	11 0	68 0	234 8	52 106

TABLE 11-5.—1990 HELICOPTER DEMAND—Continued
(MATRIX 1)

	4889														
17	1401	289	878	360	592	421	289	128	310	49	178	7	117	375	325
	13	0	0	149	247	112	114	0	75	0	4	0	0	15	128
	6574														
18	727	134	474	203	318	217	126	35	95	8	50	3	46	167	213
	41	0	0	7	54	41	38	0	38	0	4	0	0	5	36
	3085														
19	887	126	549	203	346	197	102	24	64	7	31	3	47	131	371
	376	373	22	0	147	61	37	0	54	0	6	0	0	2	19
	4162														
20	3416	474	1932	508	737	320	270	77	279	39	142	11	114	324	344
	554	1587	372	380	0	106	194	0	140	0	17	0	0	43	129
	12469														
21	757	76	386	76	121	88	114	39	132	14	57	5	32	143	204
	379	1031	369	279	172	0	177	0	39	0	5	0	0	13	22
	4731														
22	1157	173	662	173	215	101	72	20	51	5	23	1	53	58	205
	359	693	233	118	191	100	0	0	70	0	95	0	0	63	239
	5125														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	1018	190	530	98	150	76	41	10	16	0	7	0	25	25	103
	250	794	339	247	262	50	40	0	0	0	74	0	0	28	270
	4734														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	1214	288	651	108	135	53	21	2	0	0	0	0	2	1	18
	65	122	90	68	46	12	316	0	151	0	0	0	0	70	347
	3771														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	2614	579	1473	331	405	199	164	29	41	5	10	0	8	13	45
	158	204	62	11	105	24	163	0	46	0	38	0	0	0	0
	6676														
30	2171	476	1201	393	778	561	397	70	107	10	29	1	13	43	267
	353	469	126	22	113	13	181	0	114	0	71	0	0	0	0
	7978														

TABLE 11-5.—1990 HELICOPTER DEMAND—Continued
(MATRIX 2)

THE FOLLOWING IS THE DEMAND MATRIX WITHOUT MODE SPLIT.

1	154708	31613	121642	25060	9537	3088	1199	342	440	78	130	2	238	327	1688
	3477	11794	4068	2369	1009	61	411	0	77	0	30	0	0	522	5468
	379074														
2	95517	148599	134168	63993	22093	5964	2333	586	633	72	137	10	201	343	1842
	3678	10036	3675	1826	855	49	423	0	167	0	95	0	0	1212	17971
	516378														
3	210675	134275	285230	83456	29935	9599	3284	825	1630	196	299	9	449	667	3651
	7248	25593	6672	3273	1595	96	530	0	149	0	49	0	0	843	8971
	782849														
4	91803	52883	127707	186637	91109	15961	5011	1196	1394	255	412	19	370	657	3283
	6275	14241	4027	1991	954	68	371	0	61	0	23	0	0	423	3511
	626299														
5	39951	15138	47785	85488	211840	104802	13488	3310	3280	950	1058	53	420	1326	3802
	4297	9163	2396	1262	754	35	201	0	22	0	12	0	0	239	1960
	592992														
6	24311	2902	18845	13019	114616	435539	96022	17413	12181	3759	3871	327	803	4763	7149
	3188	4240	1147	572	316	21	78	0	11	0	4	0	0	68	789
	767005														
7	8251	748	4343	2163	11442	78529	244026	55287	37068	4999	6472	468	763	7052	3762
	1439	1279	318	118	136	16	16	0	1	0	1	0	0	4	166
	462899														
8	4124	548	3036	1423	6565	40704	143017	179934	102533	22096	15340	1017	877	6587	2652
	1062	842	178	61	121	20	14	0	1	0	0	0	0	6	60
	531818														
9	4445	502	3969	1416	5096	21649	93098	115567	497078	83255	133735	4195	2938	25361	7834
	2887	2405	578	206	453	84	39	0	6	0	1	0	0	5	58
	1006880														
10	2023	231	1569	656	3187	12647	36224	49564	169769	211437	91491	9094	1183	7169	3320
	1331	943	267	99	135	38	28	0	1	0	0	0	0	6	44
	602516														
11	1585	151	1402	603	2353	8505	27928	23728	191722	63934	286458	14133	2054	15377	5223
	1983	1630	421	134	289	64	35	0	4	0	0	0	0	4	34
	649748														
12	870	109	603	201	1027	3870	10998	7623	33935	21645	55381	155044	660	3656	1714
	741	587	207	67	92	27	9	0	0	0	0	0	0	9	5
	299071														
13	3609	492	2601	795	1552	2903	5656	2587	7154	1062	3562	205	110308	16149	38803
	17373	13975	3977	1787	29393	2446	1026	0	219	0	13	0	0	23	106
	264297														
14	3221	509	2565	934	2890	10270	28694	11059	32448	3817	15190	715	11672	205544	68380
	13961	5593	2534	1057	1647	325	262	0	27	0	1	0	0	12	90
	426817														
15	12714	2016	10368	3537	6561	11153	13116	3337	9023	1431	4124	268	18477	56278	475878
	132141	58961	12980	4713	6292	583	1143	0	119	0	11	0	0	48	574
	846446														
16	15738	2397	11941	3911	4192	3365	2897	766	2003	378	945	43	3754	6128	86293
	334999	144165	29431	9312	8838	515	1673	0	195	0	15	0	0	83	787
	713474														
17	36680	5358	25013	7192	7110	3265	2085	522	1382	188	730	23	4343	3668	31357
	169287	606593	142958	37240	35429	1340	5370	0	691	0	31	0	0	226	1795
	1131726														
18	16381	2339	9922	2529	2275	1346	601	117	337	25	163	7	1089	1007	6725
	[illegible]	135229	216272	84499	8346	502	6873	0	820	0	35	0	0	193	1142
	512936														

TABLE 11-5.—1990 HELICOPTER DEMAND—Continued
(MATRIX 2)

19	13158	1809	7697	1897	1859	841	462	78	218	23	98	7	849	678	4140
	13515	62749	81389	198599	7026	615	18467	0	1531	0	98	0	0	360	1730
	419865														
20	17545	2266	10182	2433	3000	1478	1601	471	1357	138	646	37	32950	2848	15542
	32966	110555	32108	16075	368001	49635	44101	0	4139	0	201	0	0	503	800
	791578														
21	2562	269	1382	282	403	342	721	280	818	72	375	25	6655	1389	3279
	3570	9342	3726	2685	63322	107198	6490	0	18453	0	131	0	0	192	139
	236102														
22	7511	1082	4265	992	1015	436	358	78	219	20	91	5	1933	474	2806
	6579	23027	19243	43335	41258	4972	193707	0	34271	0	1579	0	0	3472	2961
	395585														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	5019	1174	2787	502	591	261	143	34	55	1	27	0	589	123	695
	3073	6961	5413	8184	8674	25723	59391	0	249970	0	24338	0	0	11341	6178
	420847														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	3715	1088	2123	340	374	138	53	6	1	0	0	0	25	4	70
	222	584	426	670	467	174	3604	0	21934	0	308183	0	0	28935	6084
	379160														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	17644	6287	10901	2349	2011	763	495	82	128	12	28	0	80	50	282
	845	2391	1427	2242	1104	262	8874	0	9126	0	14050	0	0	114774	87765
	287967														
30	60198	34277	41168	8741	6774	2303	1422	229	321	26	77	3	111	159	1329
	2985	8283	3922	4756	823	100	3233	0	2614	0	1890	0	0	44927	209536
	440707														

TABLE 11-5.—1990 HELICOPTER DEMAND—Continued
(MATRIX 3)

THE FOLLOWING IS A BALANCED DEMAND MATRIX WITHOUT MODE SPLIT.

1	0	127130	332317	116863	49488	27399	9450	4466	4885	2101	1715	872	3847	3558	14402
	19211	48454	20449	15227	18554	2623	7922	0	5096	0	3745	0	0	18166	65666
	923606														
2	127130	0	238543	116653	37231	9956	3081	1134	1135	303	328	119	693	852	3858
	6075	15394	6014	3626	3121	318	1595	0	1341	0	1183	0	0	7499	52248
	639240														
3	332317	238543	0	221163	77720	27444	7627	3861	4999	1765	1701	612	3050	3232	14019
	19239	45606	16594	10970	11777	1478	4895	0	2936	0	2172	0	0	11744	50139
	1119603														
4	116863	116653	221163	0	176597	28871	7174	2619	2810	911	1012	220	1165	1591	6820
	10186	21433	6556	3983	3387	350	1363	0	563	0	363	0	0	2752	12252
	747562														
5	49488	37231	77720	176597	0	219438	24930	9875	8376	4077	3411	1080	1972	4216	13363
	8469	16273	4671	3121	3754	438	1216	0	613	0	386	0	0	2250	8734
	676879														
6	27399	9956	27444	28871	219438	0	174551	58117	33830	16406	12376	4197	3706	15033	19302
	6183	7505	2193	1413	1794	363	514	0	272	0	142	0	0	831	3592
	675028														
7	9450	3081	7627	7174	24930	174551	0	198304	130166	41223	34400	11466	6419	35146	16878
	4325	3363	919	580	1737	737	374	0	144	0	54	0	0	499	1588
	715179														
8	4466	1134	3861	2619	9875	58117	198304	0	218100	71660	39068	8640	3464	17646	5989
	1828	1364	295	139	592	300	92	0	35	0	6	0	0	38	289
	647971														
9	4885	1135	4999	2810	8376	33830	130166	218100	0	253024	325457	38130	10096	57809	16857
	4890	3787	915	424	1810	902	258	0	61	0	2	0	0	133	379
	1119235														
10	2101	303	1765	911	4077	16406	41223	71660	253024	0	155425	30739	2245	10976	4751
	1719	1131	292	122	273	110	48	0	2	0	0	0	0	18	70
	599351														
11	1715	328	1701	1012	3411	12376	34400	39068	325457	155425	0	69514	5616	30567	9347
	2925	2330	584	232	935	439	126	0	31	0	0	0	0	32	111
	697682														
12	872	119	612	220	1080	4197	11466	8640	38130	30739	69514	0	865	4371	1982
	784	610	214	74	129	52	14	0	0	0	0	0	0	0	8
	174092														
13	3847	693	3050	1165	1972	3706	6419	3464	10096	2245	5616	865	0	27821	57280
	17084	18278	5066	2536	62343	9101	3559	0	808	0	38	0	0	133	217
	247472														
14	3558	852	3232	1591	4216	15033	35146	17646	57809	10976	30567	4371	27821	0	124658
	20089	13261	3541	1735	4495	1714	736	0	150	0	5	0	0	62	249
	383513														
15	14402	3858	14019	6820	13363	19302	16878	5989	16857	4751	9347	1982	57280	124658	0
	218434	90218	19705	4953	21834	3362	3949	0	614	0	81	0	0	330	1963
	676189														
16	19211	6075	19239	10186	8469	6183	4325	1828	4890	1719	2925	784	17084	20089	218434
	0	393452	57787	22817	41814	4085	8248	0	2268	0	237	0	0	923	3772
	832454														
17	48454	15394	45606	21433	16273	7505	3363	1364	3787	1131	2330	610	18278	13261	90218
	393452	0	278087	99980	145984	13682	28397	0	7652	0	615	0	0	2617	13078
	1226551														
18	20449	6014	16594	6556	4671	2193	919	295	915	292	584	214	5066	3541	19705
	53787	278087	0	165883	40454	4228	26116	0	6233	0	451	0	0	1620	5064
	669946														

TABLE 11-5.–1990 HELICOPTER DEMAND –Continued (MATRIX 3)

19	15227	2626	10570	3888	3121	1413	580	139	424	122	232	74	2636	1735	8853
	22817	95580	165888	0	23101	3303	61802	0	9715	0	768	0	0	2602	6486
	445455														
20	18554	3121	11777	3387	3754	1794	1737	592	1810	273	935	129	62343	4495	21834
	41804	145584	40454	23101	0	112957	85359	0	12813	0	608	0	0	1607	1623
	602945														
21	2623	318	1478	350	478	363	737	300	902	110	439	52	9101	1714	3862
	4085	10682	4228	3300	112957	0	13362	0	44176	0	305	0	0	454	239
	216575														
22	7922	1505	4855	1363	1216	514	374	92	258	48	126	14	3559	736	3949
	8248	28397	26116	61802	85359	13362	0	0	93662	0	5163	0	0	12346	6194
	367240														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	5096	1341	2936	563	613	272	144	35	61	2	31	0	808	150	814
	2268	7652	6233	9715	12813	44176	93662	0	0	0	46872	0	0	20467	8792
	265516														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	3745	1183	2172	363	386	142	54	6	2	0	0	0	38	5	81
	237	615	461	769	608	305	5193	0	46872	0	0	0	0	42985	7974
	114165														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	18166	7459	11744	2752	2250	831	499	88	133	18	32	0	103	62	330
	923	2617	1620	2602	1607	454	12346	0	20467	0	42985	0	0	0	132692
	262820														
30	65666	52249	50139	12252	8734	3592	1588	289	379	70	111	8	217	249	1903
	3772	10378	5564	6496	1623	239	6194	0	8792	0	7974	0	0	132692	0
	380359														

TABLE 11-5.—1990 HELICOPTER DEMAND—Continued
(MATRIX 4)

THE FOLLOWING IS A BALANCED DEMAND MATRIX WITH MODE SPLIT.

1	0	0	0	200	970	2613	2897	1214	1722	683	669	349	659	1069	2294
	1394	1844	511	993	3591	776	1210	0	1075	0	1214	0	0	2678	2399
	33384														
2	0	0	0	7	291	678	811	262	376	93	124	47	107	234	649
	567	640	372	234	649	96	239	0	216	0	312	0	0	671	762
	8633														
3	0	0	0	14	657	1630	1943	858	1570	493	613	240	485	832	1773
	1157	1636	623	742	2226	414	752	0	563	0	667	0	0	1572	1521
	23148														
4	200	7	14	0	153	782	1379	460	798	225	343	84	171	358	820
	736	1114	546	391	710	96	235	0	112	0	116	0	0	334	612
	10846														
5	970	291	657	153	0	565	1988	775	1708	648	927	312	258	587	806
	624	1277	646	532	910	132	247	0	155	0	139	0	0	441	999
	16709														
6	2613	678	1630	782	565	0	502	353	1411	1184	1443	860	389	701	907
	500	515	424	307	378	94	116	0	79	0	54	0	0	211	716
	17686														
7	2897	811	1943	1379	1988	502	0	9	362	474	825	1273	256	83	260
	353	484	193	126	290	117	76	0	41	0	22	0	0	165	448
	15377														
8	1214	262	858	460	775	353	9	0	171	193	315	634	157	123	585
	413	355	90	43	95	44	24	0	11	0	2	0	0	31	91
	7317														
9	1722	376	1570	798	1708	1411	362	171	0	108	0	1139	392	542	1315
	899	651	247	119	365	148	59	0	18	0	1	0	0	43	128
	14491														
10	683	93	493	225	648	1184	474	193	108	0	105	217	139	409	618
	383	299	89	38	60	23	12	0	1	0	0	0	0	7	26
	6527														
11	669	124	613	343	927	1443	825	315	0	105	0	385	228	587	1177
	671	639	182	75	206	72	32	0	9	0	0	0	0	11	42
	9676														
12	349	47	240	84	312	860	1273	634	1139	217	385	0	86	541	419
	249	218	81	28	40	13	4	0	0	0	0	0	0	0	3
	7221														
13	659	107	485	171	258	389	256	157	392	139	228	86	0	53	266
	477	832	275	171	255	62	98	0	36	0	2	0	0	10	31
	5845														
14	1069	234	832	358	587	701	83	123	542	409	587	541	53	0	295
	927	1581	612	333	529	152	87	0	31	0	1	0	0	16	70
	10796														
15	2294	649	1773	820	806	907	260	585	1315	618	1177	419	266	295	0
	176	1182	642	777	450	252	282	0	122	0	21	0	0	51	399
	16686														
16	1354	567	1152	736	624	500	253	413	899	383	671	249	477	927	176
	0	19	65	524	644	430	426	0	320	0	69	0	0	115	459
	12553														
17	1844	840	1636	1114	1277	915	484	355	851	299	639	218	632	1581	1182
	19	0	0	513	1874	1143	867	0	869	0	136	0	0	220	597
	22201														
18	911	372	823	546	606	424	193	90	247	89	182	81	275	612	642
	65	0	0	29	426	419	271	0	377	0	94	0	0	67	162
	7954														

TABLE 11-5.—1990 HELICOPTER DEMAND—*Concluded*
(MATRIX 4)

19	993	234	742	391	532	307	126	43	119	38	75	28	171	338	777
	524	518	29	0	528	341	155	0	301	0	74	0	0	12	41
	7437														
20	3591	649	2226	710	910	378	290	95	365	60	206	40	255	529	490
	644	1834	426	528	0	278	385	0	403	0	63	0	0	148	242
	15742														
21	776	90	414	96	132	94	117	44	148	23	72	13	62	192	252
	430	1143	410	341	278	0	277	0	89	0	17	0	0	38	34
	5581														
22	1210	239	752	235	247	116	76	24	59	12	32	4	98	97	282
	436	867	271	155	385	277	0	0	160	0	411	0	0	226	419
	7010														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	1075	216	563	112	155	79	41	11	18	1	9	0	36	31	122
	320	869	377	301	403	89	160	0	0	0	224	0	0	74	384
	9629														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	1214	312	667	116	139	54	22	2	1	0	0	0	2	1	21
	69	126	94	74	63	17	411	0	224	0	0	0	0	108	417
	4154														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	2678	671	1572	384	441	211	165	31	43	7	11	0	10	16	51
	115	220	67	12	148	38	226	0	74	0	158	0	0	0	0
	7299														
30	2399	762	1521	612	999	716	448	91	128	26	42	3	31	70	399
	459	597	162	41	242	34	419	0	384	0	417	0	0	0	0
	11003														

TABLE II-6.—1990 TILT-ROTOR DEMAND (MATRIX 1)

USE FOLLOWING FORMAT TO READ THE DEMAND MATRIX BELOW FOR THE STOL PORTS.

DEMAND FROM STOL PORT TO ------------------------------ TO STOL PORTS ------------------------------ TOTAL DEMAND FROM STOL PORT

THE FOLLOWING IS THE DEMAND MATRIX WITH MODE SPLIT.

1	0	0	0	42	252	326	285	98	161	27	51	1	42	99	281
	274	472	194	116	198	20	59	0	18	0	10	0	0	71	251
	3349														
2	0	0	0	5	234	499	474	148	218	23	53	4	31	98	331
	382	604	256	119	188	15	72	0	29	0	26	0	0	104	320
	4233														
3	0	0	0	7	350	624	637	201	351	61	113	4	72	179	505
	508	825	377	215	317	30	98	0	35	0	16	0	0	111	356
	5901														
4	223	5	15	0	123	593	638	241	430	72	148	7	57	156	437
	513	833	374	208	217	21	68	0	14	0	8	0	0	61	243
	5754														
5	859	112	417	69	0	299	1092	290	735	143	297	13	50	179	298
	323	753	313	205	185	11	36	0	5	0	4	0	0	41	243
	6973														
6	2570	267	1179	311	358	0	3	103	573	265	438	60	73	193	300
	256	544	224	122	63	6	16	0	3	0	1	0	0	14	169
	8113														
7	2675	215	1183	470	1092	9	0	4	160	88	191	58	28	16	73
	137	216	73	27	22	3	4	0	0	0	0	0	0	1	55
	6762														
8	1258	139	734	268	580	326	9	0	128	80	164	78	49	61	314
	266	243	59	20	71	5	4	0	0	0	0	0	0	2	21
	4784														
9	1623	175	1302	420	1108	1049	285	77	0	36	0	76	107	203	647
	573	595	165	69	94	18	9	0	2	0	0	0	0	1	22
	8648														
10	703	77	474	175	582	1086	491	143	99	0	71	42	80	282	483
	373	274	88	34	33	10	7	0	0	0	0	0	0	2	17
	5592														
11	627	74	521	212	693	1183	795	211	1	54	0	32	98	334	760
	507	498	141	47	70	15	10	0	2	0	0	0	0	1	13
	6890														
12	348	44	239	79	323	859	1403	670	1275	225	427	0	83	521	412
	265	221	81	26	71	9	3	0	0	0	0	0	0	0	2
	7575														
13	663	86	453	131	234	357	264	137	364	86	176	20	0	47	239
	469	802	260	141	167	36	52	0	13	0	1	0	0	2	19
	5219														
14	1021	151	704	229	461	552	92	87	451	200	366	95	26	0	218
	706	1342	490	230	226	55	34	0	6	0	0	0	0	3	29
	7904														
15	2172	369	1415	459	581	594	237	331	832	213	559	56	77	136	0
	160	1314	509	468	171	55	88	0	21	0	3	0	0	7	142
	10[illegible]														
16	1228	236	749	296	357	294	254	178	417	83	229	13	80	273	68
	0	19	35	207	110	58	79	0	33	0	4	0	0	9	116

TABLE II-6.—1990 TILT ROTOR DEMAND—Continued
(MATRIX 1)

	5425														
17	1494	317	958	398	645	460	322	138	339	54	195	8	134	423	388
	19	0	0	173	295	125	126	0	83	0	4	0	0	18	141
	7256														
18	769	146	514	221	343	233	138	37	102	8	54	3	54	185	253
	57	0	0	10	68	46	44	0	44	0	4	0	0	5	40
	3380														
19	963	179	606	224	374	212	145	26	69	8	33	3	54	146	425
	423	429	33	0	173	69	44	0	61	0	7	0	0	3	21
	4690														
20	3631	509	2074	548	784	344	299	86	305	33	155	12	135	359	405
	647	1829	451	447	0	124	224	0	161	0	20	0	0	51	141
	13774														
21	705	81	410	82	128	96	129	45	149	16	65	5	39	162	238
	429	1150	419	317	263	0	201	0	45	0	6	0	0	16	23
	5247														
22	1246	187	729	188	232	109	90	22	56	6	25	1	62	66	233
	305	762	268	140	221	114	0	0	85	0	107	0	0	76	263
	5666														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	1106	268	577	198	162	81	44	11	17	0	8	0	29	28	115
	322	874	384	242	302	58	108	0	0	0	87	0	0	32	301
	5274														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	1265	309	691	114	139	54	21	2	0	0	0	0	2	1	20
	69	133	97	77	52	13	360	0	176	0	0	0	0	84	407
	4986														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	2868	651	1637	370	447	217	174	30	44	5	11	0	9	15	52
	123	235	73	14	122	28	149	0	53	0	47	0	0	0	3
	7427														
30	2377	537	1337	442	856	611	426	75	112	10	29	1	15	46	290
	787	522	141	25	125	14	232	0	127	0	83	0	0	1	0
	8792														

TABLE II-6.—1990 TILT-ROTOR DEMAND—Continued
(MATRIX 2)

THE FOLLOWING IS THE DEMAND MATRIX WITHOUT MODE SPLIT.

1	154738	31613	121642	25060	9577	3088	1199	342	440	78	130	2	238	327	1688
	3473	11794	4068	2069	1009	61	411	0	77	0	39	0	0	522	5468
	379074														
2	95517	148599	134168	63993	22093	5864	2333	586	633	72	137	10	201	343	1842
	3678	11076	3675	1826	855	49	423	0	167	0	95	0	0	1212	17971
	516378														
3	210675	194375	285230	83456	29935	8599	3284	825	1033	196	299	9	449	667	3651
	7298	20593	6672	3273	1595	96	630	0	149	0	49	0	0	843	9971
	782949														
4	91883	52660	137707	186637	91109	15861	5011	1196	1394	255	412	19	370	657	3283
	6775	14741	4627	1991	954	69	371	0	61	0	23	0	0	403	3511
	623209														
5	39951	15138	47785	85488	211840	104822	13488	3310	3289	850	1058	53	420	1326	3802
	4297	9163	2396	1262	754	35	201	0	22	0	12	0	0	279	1969
	552952														
6	24311	3592	18845	13010	114616	435539	96022	17413	12181	3759	3871	327	803	4763	7149
	3159	4240	1147	572	316	21	78	0	11	0	4	0	0	68	789
	757035														
7	8251	748	4347	2163	11442	78529	244029	55287	37069	4999	6472	469	763	7052	3762
	1478	1278	318	118	176	16	16	0	1	0	1	0	0	4	166
	468859														
8	4174	548	3036	1423	6565	40704	143017	178934	102533	22096	15349	1017	877	6587	2652
	1062	842	179	61	121	20	14	0	1	0	0	0	0	6	60
	531818														
9	4445	502	3969	1416	5096	21649	93098	115567	497078	83255	133735	4195	2938	25361	7834
	2887	2405	578	296	453	84	39	0	5	0	1	0	0	5	58
	1006860														
10	2023	231	1569	656	7187	12647	36224	49564	169769	211437	91491	9094	1183	7169	3329
	1381	943	267	99	135	38	28	0	1	0	3	0	0	6	44
	602595														
11	1585	191	1403	600	2252	8505	27928	23728	191722	63934	286458	14133	2054	15377	5223
	1040	1679	421	134	289	64	35	0	4	0	0	0	0	4	34
	649788														
12	970	109	603	201	1027	3870	11998	7623	33935	21645	55381	155344	660	3656	1714
	741	597	207	67	92	27	9	0	0	0	0	0	0	0	5
	299371														
13	7609	492	2601	795	1552	2903	5656	2587	7158	1062	3562	205	110308	16149	38803
	13330	13575	3977	1787	22793	2446	1676	0	213	0	13	0	0	23	106
	254297														
14	3231	509	2565	934	2890	10270	28094	11059	32449	3607	15193	715	11672	205544	68380
	13051	9597	2534	1057	1647	325	262	0	27	0	1	0	0	12	90
	428817														
15	12714	2016	10368	3537	6561	11853	13116	3337	9923	1431	4124	259	18477	56278	475878
	132141	59861	12940	4713	6292	587	1143	0	119	0	11	0	0	48	574
	846446														
16	15778	3367	11941	3911	4192	3025	2897	766	2053	338	945	43	3754	6128	86293
	374190	184165	29431	9312	8838	515	1673	0	195	0	15	0	0	83	787
	713474														
17	36660	6358	25613	7192	7110	3265	2085	522	1382	188	709	23	4343	3668	31357
	169287	603593	142858	37240	35429	1340	5370	0	691	0	31	0	0	226	1795
	1131726														
18	16341	2379	9322	2529	2275	1046	691	117	337	25	163	7	1089	1007	6725
	24756	135329	236272	84499	8746	502	6873	0	429	0	35	0	0	193	1142
	[illegible]														

TABLE II-6.—1990 TILT-ROTOR DEMAND—Continued
(MATRIX 2)

19	13158	1800	7697	1897	1859	841	462	78	218	23	98	7	849	678	4140
	13505	62740	81389	198599	7026	615	18467	0	1531	0	98	0	0	360	1730
	419865														
20	17545	2266	10182	2433	3000	1478	1601	471	1357	138	646	37	32950	2848	15542
	32966	110555	32108	16075	368001	49635	44101	0	4139	0	201	0	0	503	800
	751578														
21	2562	269	1382	282	403	342	721	280	818	72	375	25	6655	1389	3279
	3570	9342	3726	2685	63322	107198	8490	0	18453	0	131	0	0	192	139
	236102														
22	7511	1082	4265	992	1015	436	358	78	219	20	91	5	1933	474	2806
	6575	23027	10243	43335	41258	4872	193707	0	34271	0	1579	0	0	3472	2961
	335585														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	5019	1174	2787	502	591	261	143	34	55	1	27	0	589	123	695
	2073	5561	5413	9184	8674	25723	59391	0	249970	0	24938	0	0	11341	6178
	420947														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	3715	1588	2123	340	374	138	53	6	1	0	0	0	25	4	70
	222	584	426	670	407	174	3604	0	21934	0	308183	0	0	28935	6084
	379160														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	17644	6287	10901	2349	2011	763	495	82	128	12	28	0	80	50	282
	840	2391	1427	2242	1104	262	8874	0	9126	0	14050	0	0	114774	87765
	283967														
30	60198	34277	41168	8741	6774	2803	1422	229	321	26	77	3	111	159	1329
	2985	9283	3922	4756	823	100	3233	0	2614	0	1890	0	0	44927	209536
	440767														

TABLE II-6.—1990 TILT-ROTOR DEMAND—Continued (MATRIX 3)

THE FOLLOWING IS A BALANCED DEMAND MATRIX WITHOUT MODE SPLIT.

1	0	127130	332317	115863	49488	27399	9450	4466	4885	2101	1715	872	3847	3558	14402
	19211	48454	20449	15227	18554	2623	7922	0	5096	0	3745	0	0	18166	65666
	927626														
2	127130	0	238543	116653	37231	9856	3081	1134	1135	303	328	119	693	852	13858
	6075	15354	6014	3626	3121	318	1505	0	1341	0	1183	0	0	7499	52248
	539740														
3	332317	238543	0	221163	77720	27444	7627	3861	4999	1765	1791	612	3050	3232	14019
	19239	45606	16594	10970	11777	1478	4895	0	2936	0	2172	0	0	11744	51139
	1115603														
4	115863	116653	221163	0	176597	28871	7174	2619	2810	911	1012	220	1165	1591	5829
	10186	21433	6556	3888	3387	350	1363	0	563	0	363	0	0	2752	12252
	747662														
5	49488	37231	77720	176597	0	219438	24930	9875	8376	4037	3411	1080	1972	4216	10363
	8489	16273	4671	3121	3754	438	1216	0	613	0	386	0	0	2250	3734
	678679														
6	27399	9856	27444	28871	219438	0	174551	58117	33830	16406	12376	4197	3706	15033	19002
	6183	7505	2193	1413	1794	363	514	0	272	0	142	0	0	831	3592
	675528														
7	9450	3081	7627	7174	24930	174551	0	198304	130166	41223	34400	11466	6419	35146	16878
	4325	3363	919	580	1737	737	374	0	144	0	54	0	0	499	1588
	715175														
8	4466	1134	3861	2619	9875	58117	198304	0	218100	71660	39068	8640	3464	17646	5989
	1828	1364	295	139	592	300	92	0	35	0	6	0	0	98	289
	647971														
9	4885	1135	4999	2810	8376	33830	130166	218100	0	253024	325457	38130	10096	57809	16857
	4893	3797	915	424	1810	902	259	0	61	0	2	0	0	133	379
	1119275														
10	2101	303	1765	911	4037	16406	41223	71660	253024	0	155425	30739	2245	10976	4751
	1719	1131	292	122	273	110	48	0	2	0	0	0	0	18	70
	539361														
11	1715	328	1791	1012	3411	12376	34400	39068	325457	155425	0	69514	5616	30567	9347
	2925	2330	584	232	935	439	126	0	31	0	0	0	0	32	111
	697842														
12	872	119	612	220	1080	4197	11466	8640	38130	30739	69514	0	865	4371	1982
	784	610	214	74	129	52	14	0	0	0	0	0	0	0	8
	174692														
13	3847	693	3050	1165	1972	3706	6419	3464	10096	2245	5616	965	0	27821	57280
	17084	18278	5066	2676	62747	9101	3559	0	908	0	38	0	0	103	217
	247472														
14	3558	852	3232	1591	4216	15033	35146	17646	57809	10976	30567	4371	27821	0	124658
	20089	13261	3541	1735	4495	1714	736	0	153	0	5	0	0	62	249
	353513														
15	14402	13858	14019	6820	10363	19002	16878	5989	16857	4751	9347	1982	57280	124658	0
	219434	93218	19705	8853	21834	3862	3949	0	814	0	81	0	0	330	1903
	676189														
16	19211	6075	19239	10186	8489	6183	4325	1828	4893	1719	2925	784	17084	20089	219434
	0	353452	53787	22817	41804	4085	8249	0	2268	0	237	0	0	923	3772
	832854														
17	48454	15394	45606	21433	16273	7565	3363	1364	3797	1131	2330	610	18278	13261	93219
	353452	0	273087	93980	145984	10682	28797	0	7652	0	615	0	0	2617	11078
	1226551														
18	20449	6014	16594	6556	4671	2193	919	295	915	292	584	214	5056	3541	19705
	53787	273087	0	165883	40464	4228	26116	0	6233	0	461	0	0	1620	5064
	669946														

TABLE II-6.—1990 TILT-ROTOR DEMAND—Continued (MATRIX 3)

19	15227	3626	10970	3888	3121	1413	580	139	424	122	232	74	2636	1735	8853
	22817	99580	165899	0	23101	3300	61802	0	9715	0	768	0	0	2602	6486
	449499														
20	18554	3121	11777	3397	3754	1794	1737	592	1810	273	935	129	62343	4495	21834
	41864	145584	40454	23101	0	112957	85359	0	12813	0	608	0	0	1607	1623
	602445														
21	2623	318	1478	350	478	363	737	300	902	110	439	52	9101	1714	3862
	4085	10682	4228	3300	112957	0	13362	0	44176	0	305	0	0	454	239
	216575														
22	7092	1505	4895	1363	1216	514	374	92	259	48	126	14	3559	736	3949
	8248	28397	26116	61802	85359	13362	0	0	93662	0	5183	0	0	12346	6194
	367240														
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
24	5106	1341	2936	563	613	272	144	35	61	2	31	0	808	150	814
	2268	7652	6233	9715	12813	44176	93662	0	0	0	46872	0	0	20467	8792
	265516														
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
26	3745	1183	2172	363	386	142	54	6	2	0	0	0	38	5	81
	237	615	461	768	608	305	5183	0	46872	0	0	0	0	42985	7974
	114195														
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0														
29	18166	7499	11744	2752	2250	831	499	88	133	18	32	0	103	62	330
	923	2617	1623	2602	1607	454	12346	0	20467	0	42985	0	0	0	132692
	262820														
30	65666	52248	50139	12252	8734	3592	1593	289	379	70	111	8	217	249	1903
	3772	10078	5064	6486	1623	239	6194	0	8792	0	7974	0	0	132692	0
	380350														

TABLE II-6.—1990 TILT-ROTOR DEMAND—Continued
(MATRIX 4)

THE FOLLOWING IS A BALANCED DEMAND MATRIX WITH MODE SPLIT.

1	0	0	0	265	1111	2896	2960	1306	1784	730	678	349	705	1120	2453
	1502	1966	963	1079	3829	815	1304	0	1114	0	1275	0	0	2940	2628
	35773														
2	0	0	0	10	346	767	689	286	394	100	127	48	117	249	700
	618	521	402	258	697	96	260	0	237	0	335	0	0	755	858
	9267														
3	0	0	0	22	767	1803	1820	935	1653	535	634	242	525	882	1920
	1257	1784	891	820	2391	440	818	0	612	0	707	0	0	1748	1694
	24900														
4	265	10	22	0	192	904	1119	509	851	247	360	86	188	385	896
	899	1231	595	432	764	103	256	0	122	0	123	0	0	471	685
	11583														
5	1111	346	767	192	0	657	2184	870	1843	725	990	336	283	639	979
	679	1398	655	579	969	139	269	0	167	0	143	0	0	488	1099
	18409														
6	2896	767	1803	904	657	0	12	430	1622	1352	1622	959	430	785	894
	550	1004	457	334	407	102	126	0	94	0	55	0	0	231	779
	19261														
7	2960	689	1820	1119	2184	12	0	13	445	579	976	1461	292	108	310
	401	539	210	172	321	132	84	0	44	0	22	0	0	175	481
	15548														
8	1306	286	935	509	870	430	13	0	205	223	379	748	186	148	646
	443	381	95	46	107	51	26	0	12	0	2	0	0	32	96
	8174														
9	1784	394	1653	851	1843	1622	445	205	0	135	1	1351	471	654	1479
	990	934	267	130	399	167	65	0	19	0	1	0	0	46	134
	16039														
10	730	100	535	247	725	1352	579	223	135	0	126	267	167	482	696
	422	327	96	41	66	26	13	0	1	0	0	0	0	7	27
	7390														
11	678	127	634	360	990	1622	976	379	1	126	0	459	274	699	1319
	336	692	195	80	225	81	75	0	13	0	0	0	0	12	43
	10783														
12	349	48	242	86	336	959	1461	748	1351	267	459	0	103	616	468
	268	228	83	29	42	14	4	0	0	0	0	0	0	0	3
	8165														
13	705	117	525	188	283	430	292	186	471	167	274	103	0	72	316
	550	637	314	195	302	75	114	0	42	0	3	0	0	11	34
	6707														
14	1120	249	882	385	639	785	108	149	654	482	699	616	72	0	355
	1169	1765	674	376	585	217	100	0	34	0	1	0	0	18	75
	12108														
15	2453	700	1920	896	979	894	310	646	1479	696	1319	468	316	355	0
	228	1403	762	894	576	292	320	0	136	0	22	0	0	59	432
	18955														
16	1092	618	1257	839	679	550	401	443	990	422	736	268	550	1069	228
	0	28	92	630	758	487	474	0	355	0	72	0	0	132	503
	14053														
17	1966	521	1784	1231	1398	1004	538	381	934	327	692	228	937	1765	1403
	28	0	0	601	2124	1275	887	0	956	0	137	0	0	253	663
	22435														
18	963	402	891	595	655	457	219	96	367	96	195	83	314	674	762
	92	0	0	44	519	466	312	0	428	0	101	0	0	79	181
	8844														

TABLE II-6.—1990 TILT-ROTOR DEMAND—Concluded
(MATRIX 4)

19	1079 630 8421	258 601	820 44	432 0	579 620	334 386	172 184	46 0	130 343	41 0	80 84	29 0	195 0	376 17	894 47
20	3829 798 17447	697 2124	2391 519	764 620	969 0	407 327	321 444	107 0	399 463	66 0	225 72	42 0	302 0	585 172	576 266
21	815 487 6207	96 1275	440 465	103 386	139 327	102 0	132 315	51 0	167 103	26 0	81 19	14 0	75 0	217 44	292 38
22	1114 474 7812	260 887	818 312	256 184	269 444	126 315	84 0	26 0	65 193	13 0	35 467	4 0	114 0	190 276	320 465
23	0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
24	1114 755 6252	237 556	612 428	122 343	167 463	84 193	44 193	12 0	19 0	1 0	10 263	0 0	42 0	34 85	136 428
25	0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
26	1375 72 4525	335 137	707 101	123 84	143 72	55 19	22 467	2 0	1 263	0 0	0 0	0 0	3 0	1 130	22 490
27	0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
28	0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
29	2940 132 9145	755 253	1748 79	431 17	488 172	231 44	175 276	32 0	46 85	7 0	12 130	0 0	11 0	18 0	59 3
30	2628 593 12152	859 663	1694 181	685 47	1099 266	779 38	481 465	96 0	134 429	27 0	43 490	3 0	34 0	75 3	432 0

TABLE 11-7.–TRAFFIC DATA–1980 BASE CASE
(Two-Way Passengers Per Day)

From	To	STOL		VTOL	
		Demand	Distance	Demand	Distance
1	5	804	13	819	12
	6	2525	21	2078	21
	7	2185	28	1708	28
	8	947	34	730	34
	9	1219	39	862	39
	13	555	32		
	14	1047	28	824	28
	15	2346	18	1932	18
	16	1485	10	1220	10
	17	1014	7	1666	7
	18	937	13	748	7
	19			784	13
	20	2448	23	2548	21
	21	601	34		
	22	556	23	850	22
	24	672	30	510	30
	26	652	42	522	42
	29	1568	26	1096	26
	30	1515	11	1339	11
2	6	825	22	567	22
	7	757	29	629	29
	15	815	21	518	21
	16	732	14		
	17	597	11	731	12
	20	608	27		
	29	651	26		
	30	785	11	610	11
3	5			539	11
	6	692	19	1207	20
	7	873	26	1190	27
	9	871	38	750	39
	14	565	27	560	29
	15	979	16	1374	18
	16			945	11
	17			1390	9
	18			627	9
	19			531	15
	20	962	23	1409	23
	29	516	27	735	27
	30	544	13	1076	12
4	6			617	18
	7	803	27	936	26
	15	506	21	646	20
	16			607	14
	17			969	14

TABLE 11-7.–TRAFFIC DATA–1980 BASE CASE–Continued
(Two-Way Passengers Per Day)

From	To	STOL		VTOL	
		Demand	Distance	Demand	Distance
5	1	804	13	819	12
	3			539	11
	7	1050	17	1583	18
	8	652	23	581	23
	9	1685	30	1184	31
	11	734	36	612	37
	15	655	14	652	15
	16	579	13	537	13
	17	800	18	1136	16
	18	514	25	520	17
	20	558	31	605	28
	30	732	23	723	23
6	1	2525	21	2078	21
	2	825	22	567	22
	3	692	19	1207	20
	4			617	18
	9	1252	21	1016	21
	10			710	25
	11	1097	27	792	27
	12	589	41		
	15	677	13	615	12
	16	504	17		
	17	633	25	691	22
7	1	2185	28	1708	28
	2	757	29	629	29
	3	873	26	1190	27
	4	803	27	936	26
	5	1050	17	1583	18
	11	635	19	545	19
	12	1005	33	736	34
8	1	947	34	730	34
	5	652	23	581	23
9	1	1219	39	862	39
	3	871	38	750	39
	5	1685	30	1184	31
	6	1252	21	1016	21
	12	908	21	782	21
	15	1321	23	1009	23
	16	1109	31	633	31
	17	593	41	647	37
10	6			710	25
11	5	734	36	612	37
	6	1097	27	792	27
	7	635	19	545	19
	15	971	28	704	28
	16	688	36		

TABLE 11-7.—TRAFFIC DATA—1980 BASE CASE—Continued
(Two-Way Passengers Per Day)

From	To	STOL		VTOL	
		Demand	Distance	Demand	Distance
12	6	589	41		
	7	1005	33	736	34
	9	908	21	782	21
13	1	555	32		
	17			505	26
14	1	1047	28	824	28
	3	565	27	560	29
	16	1012	19	711	19
	17	1007	28	1135	25
15	1	2346	18	1932	18
	2	815	21	518	21
	3	979	16	1374	18
	4	506	21	646	20
	5	655	14	652	15
	6	677	13	615	12
	9	1321	23	1009	23
	11	971	28	704	28
	17	695	18	914	14
	18	769	26		
16	1	1485	10	1220	10
	2	732	14		
	3			945	11
	4			607	14
	5	579	13	537	13
	6	504	17		
	9	1109	31	633	31
	11	688	36		
	14	1012	19	711	19
17	1	1014	7	1666	7
	2	597	11	731	12
	3			1390	9
	4			969	14
	5	800	18	1136	16
	6	633	25	691	22
	9	593	41	647	37
	13			505	26
	14	1007	28	1135	25
	15	695	18	914	14
	20			1243	14
	21			533	27
	22			636	18
	24	524	24		
18	1	937	13	748	7
	3			627	9
	5	514	24	520	17
	15	769	26		

TABLE 11-7.–TRAFFIC DATA–1980 BASE CASE–Concluded
(Two-Way Passengers Per Day)

From	To	STOL		VTOL	
		Demand	Distance	Demand	Distance
19	1			784	13
	3			531	15
20	1	2448	23	2548	21
	2	608	27		
	3	962	23	1409	23
	5	558	31	605	28
	17			1243	14
21	1	601	34		
	17			533	27
22	1	556	23	850	22
	17			636	18
24	1	672	30	510	30
	17	524	24		
26	1	652	42	522	42
29	1	1568	26	1096	26
	2	651	26		
	3	516	27	735	27
30	1	1515	11	1339	11
	2	785	11	610	11
	3	544	13	1076	12
	5	732	23	723	23

TABLE 11-8.–TRAFFIC DATA–1990 BASE CASE
(Two-Way Passengers Per Day)

From	To	STOL		VTOL		
		Demand	Distance	Tilt-rotor demand	Helicopter demand	Distance
1	5	851	13	1111	970	12
	6	2959	21	2896	2613	21
	7	3223	28	2960	2897	28
	8	1391	34	1306	1214	34
	9	2303	39	1784	1722	39
	10			730	683	45
	11	740	45	678	669	45
	13	741	32	705	659	32
	14	1226	28	1120	1069	28
	15	2678	18	2453	2294	18
	16	1623	10	1502	1392	10
	17	1175	7	1966	1844	7
	18	1146	13	963	911	7
	19	540	21	1079	993	13
	20	3135	23	3829	3591	21
	21	946	34	815	776	34
	22	731	23	1304	1210	22
	24	1144	30	1114	1035	30
	26	1350	42	1275	1214	42
	29	3007	26	2940	2678	26
	30	2403	11	2628	2399	11
2	6	924	22	767	678	22
	7	912	29	689	811	29
	9	637	42			
	15	978	21	700	1649	21
	16	826	14	618	567	14
	17	694	11	921	840	12
	20	825	27	697	649	26
	29	981	26	755	671	26
	30	907	11	858	762	11
3	5			767	647	11
	6	869	19	1803	1600	20
	7	1332	26	1820	1943	27
	8	679	32	935	858	33
	9	1690	38	1653	1570	39
	10			535		45
	11	601	43	634	613	45
	13			525		33
	14	716	27	882	832	29
	15	1196	16	1920	1773	18
	16	579	10	1257	1152	11
	17	520	8	1784	1636	9
	18	562	14	891	823	9
	19			820	742	15
	20	1317	23	2391	2226	23

TABLE 11-8.–TRAFFIC DATA–1990 BASE CASE –Continued
(Two-Way Passengers Per Day)

From	To	STOL		VTOL		
		Demand	Distance	Tilt-rotor demand	Helicopter demand	Distance
3	22			818	752	24
	24			612	563	32
	26			707	667	43
	29	1027	27	1748	1572	27
	30	889	13	1694	1521	12
4	6			904	782	18
	7	934	27	1119	1379	26
	8			509		31
	9	555	40	851	798	38
	15	583	21	896	820	20
	16	543	16	809	736	14
	17	503	15	1231	1114	14
	18			595	546	14
	20			764	710	28
	30			685	612	16
5	1	851	13	1111	970	12
	3			767	657	11
	6			657	565	10
	7	1252	17	2184	1988	18
	8	763	23	870	775	23
	9	2103	30	1843	1708	31
	10			725	648	35
	11	1021	36	990	927	37
	14	593	22	639	587	23
	15	757	14	879	806	15
	16	629	13	679	624	13
	17	868	18	1398	1277	16
	18	576	25	655	606	17
	19			579	532	25
	20	673	31	969	910	28
	30	934	23	1099	999	23
6	1	2959	21	2896	2613	21
	2	924	22	767	678	22
	3	869	19	1803	1600	20
	4			904	782	18
	5			657	565	10
	7				502	8
	9	1582	21	1622	1411	21
	10	668	27	1352	1184	25
	11	1513	27	1622	1443	27
	12	929	41	959	860	42
	14	701	16	785	701	16
	15	825	13	894	807	12
	16	660	17	550		16
	17	805	25	1004	915	22
	30	746	32	779	716	32

TABLE 11-8.–TRAFFIC DATA–1990 BASE CASE–Continued
(Two-Way Passengers Per Day)

From	To	STOL Demand	STOL Distance	VTOL Tilt-rotor Demand	VTOL Helicopter Demand	VTOL Distance
7	1	3223	28	2960	2897	28
	2	916	29	689	811	27
	3	1332	26	1820	1943	30
	4	934	27	1119	1379	26
	5	1252	17	2184	1988	18
	6				502	8
	10			479		18
	11	848	19	976	825	19
	12	1363	33	1461	1273	34
	17			538		27
8	1	1391	34	1306	1214	34
	3	679	32	935	856	33
	4			509		31
	5	763	23	870	775	23
	12	680	29	748	634	29
	15	612	21	646	585	21
	16	526	28			
9	1	2303	39	1784	1722	39
	2	637	42			
	3	1690	38	1653	1570	39
	4	555	40	851	798	38
	5	2103	30	1843	1708	31
	6	1582	21	1622	1411	21
	12	1171	21	1351	1139	21
	14	540	14	654	542	14
	15	1533	23	1479	1315	23
	16	1324	31	990	899	31
	17	710	41	934	851	37
10	1			730	683	45
	3			535		45
	5			725	648	35
	6	668	27	1352	1148	25
	7			579		18
	15			696	618	31
11	1	740	45	678	669	45
	3	601	43	634	613	45
	5	1021	36	990	927	37
	6	1513	27	1622	1443	27
	7	848	19	976	825	19
	14	597	17	699	587	17
	15	1239	28	1319	1177	28
	16	880	36	736	671	36
	17			692	639	42
12	6	919	41	959	860	42
	7	1363	33	1461	1273	34
	8	680	29	748	634	29
	9	1171	21	1351	1139	21
	14	578	33	616	541	33

TABLE 11-8.—TRAFFIC DATA—1990 BASE CASE—Continued
(Two-Way Passengers Per Day)

From	To	STOL Demand	STOL Distance	VTOL Tilt-rotor demand	VTOL Helicopter demand	VTOL Distance
13	1	741	32	705	659	32
	3			525		33
	16	612	22	550		22
	17	564	29	937	832	26
14	1	1226	28	1120	1069	28
	3	716	27	882	832	29
	5	593	22	639	587	23
	5	691	15	675	691	15
	9	540	14	654	542	14
	11	597	17	699	587	17
	12	578	33	616	541	33
	16	1191	19	1069	927	19
	17	1203	28	1765	1581	25
	18			674	612	28
	20			585	529	26
15	1	2678	18	2453	2294	18
	2	978	21	700	649	21
	3	1196	16	1920	1773	18
	4	583	21	896	820	20
	5	757	14	879	806	15
	6	825	13	894	807	12
	8	612	14	646	585	14
	9	1533	21	1479	1315	21
	10			696	618	23
	11	1239	34	1319	1177	31
	17	837	18	1403	1182	14
	18	885	26	762	642	18
	19			894	777	26
	20			576		19
16	1	1623	10	1502	1394	10
	2	826	14	618	1567	14
	5	629	13	679	624	13
	6	660	17	550		16
	8	526	28			
	9	1324	31	990	899	31
	11	880	36	736	671	36
	13	612	22	550		22
	14	1191	19	1069	927	19
	18	577	18			
	19			630	524	18
	20	657	18	758	644	15
	21	620	27			
	30	543	20	503		21
17	1	1175	7	1966	1844	7
	2	694	11	921	840	12
	3	520	8	1784	1636	9

TABLE 11-8.–TRAFFIC DATA–1990 BASE CASE–Continued
(Two-Way Passengers Per Day)

From	To	STOL		VTOL		
		Demand	Distance	Tilt-rotor demand	Helicopter demand	Distance
17	4	503	15	1231	1114	14
	5	868	18	1398	1277	16
	6	805	25	1004	915	22
	7			538		27
	9	710	41	934	851	37
	11			692	639	42
	13	564	29	937	832	26
	14	1203	28	1765	1581	25
	15	837	18	1403	1182	14
	19			601	518	12
	20			2124	1834	14
	21	884	29	1275	1143	27
	22			887	807	18
	24	787	24	956	869	27
	30			663	597	15
18	1	1146	13	963	911	7
	3	562	14	891	823	9
	4			595	546	14
	5	576	25	655	606	17
	14			674	612	28
	15	885	26	762	642	18
	16	577	18			
	20			519		15
19	1	540	21	1079	993	13
	3			820	742	15
	5			579	532	25
	15	894	777	26		
	16	630	524	18		
	17	601	518	12		
	20			620	528	18
20	1	3135	23	3829	3591	21
	2	825	27	697	649	26
	3	1317	23	2391	2226	23
	4			764	710	28
	5	673	31	969	910	28
	14			585	529	26
	15			576		19
	16	657	18	758	644	15
	17			2124	1834	14
	18			519		15
	19			620	528	18
21	1	946	34	815	776	34
	16	620	27			
	17	884	29	1275	1143	27
22	1	731	23	1304	1210	22
	3			818	752	24
	17			887	807	18

TABLE 11-8.—TRAFFIC DATA—1990 BASE CASE—Concluded
(Two-Way Passengers Per Day)

From	To	STOL Demand	STOL Distance	VTOL Tilt-rotor demand	VTOL Helicopter demand	VTOL Distance
24	1	1144	30	1114	1035	30
	3			612	563	32
	17	787	24	956	869	27
26	1	1350	42	1275	1214	42
	3			707	667	43
29	1	3007	26	2940	2678	26
	2	981	26	755	671	26
	3	1027	27	1748	1572	26
30	1	2403	11	2628	2399	11
	2	907	11	858	762	11
	3	889	13	1694	1521	12
	4			685	612	16
	5	937	23	1099	999	23
	6	746	32	779	716	32
	16	543	20	503		21
	17			663	597	15

TABLE 11-9.—AIRCRAFT DATA—1975 AIRCRAFT

Type	Seats	DOC intercept, $	DOC slope, $/st mi	Daily depreciation, $	Daily insurance, $	Block time intercept, min	Block time slope, min/st mi
Augmentor wing	49	34.55	0.5048	457.87	99.30	4.614	0.16226
Augmentor wing	95	45.42	0.6447	577.65	125.35	4.614	0.16226
Augmentor wing	153	61.24	0.8170	725.60	157.45	4.614	0.16226
Helicopter	50	31.46	1.0738	487.85	106.82	4.03	0.3078
Helicopter	98	45.59	1.4738	686.00	149.49	4.003	0.3035
Helicopter	150	57.33	1.8232	847.10	184.20	4.001	0.3011

TABLE 11-10.—AIRCRAFT DATA—1985 AIRCRAFT

Type	Seats	DOC intercept, $	DOC slope, $/st mi	Daily depreciation, $	Daily insurance, $	Block time intercept, min	Block time slope, min/st mi
Augmentor wing	49	29.49	0.4375	460.62	100.00	4.627	0.16116
	95	38.68	0.5496	575.64	125.03	4.627	0.16116
	153	51.24	0.69389	717.33	155.80	4.627	0.16116
Helicopter	50	25.43	0.7838	482.32	105.73	4.002	0.2473
	98	36.66	1.0741	678.20	147.96	4.002	0.2436
	150	47.33	1.3638	843.52	183.50	4.002	0.2416
Tilt rotor	50	24.65	0.4631	453.71	99.49	4.002	0.1727
	100	37.40	0.5792	676.40	147.96	4.002	0.1539
	150	48.71	0.7032	865.24	189.11	4.002	0.1487

TABLE 11-11.—NETWORK MODEL RESULTS—49-SEAT 1975 AUGMENTOR WING STOL

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	6.25	1289	.593	.598	1059.2	4512.17	2611.53	0.00	1900.64	1901	.0214
2	7.38	1652	.601	.513	1166.6	5782.15	3046.30	0.00	2735.76	4636	.0489
3	6.82	1619	.689	.688	1158.4	5665.73	2800.35	0.00	2865.38	7502	.0759
4	8.34	1707	.610	.622	1491.8	5975.37	3245.05	0.00	2730.32	10232	.1043
5	7.38	1539	.637	.628	1308.3	5385.74	2945.08	0.00	2440.66	12673	.1299
6	7.29	1713	.672	.660	1188.2	5994.65	2988.13	0.00	3006.53	15679	.1584
7	6.25	1289	.581	.572	1001.8	4511.14	2652.16	0.00	1858.98	17538	.1798
8	5.98	1261	.594	.613	1018.3	4413.38	2522.29	0.00	1891.10	19429	.2008
9	5.15	1119	.576	.585	793.7	3916.17	2305.29	0.00	1610.78	21040	.2194
10	5.25	944	.506	.535	916.3	3304.47	2263.54	0.00	1040.93	22081	.2351
11	4.94	1031	.568	.569	775.3	3608.95	2226.90	0.00	1382.05	23463	.2523
12	5.18	999	.492	.523	805.8	3496.14	2311.40	0.00	1184.73	24648	.2689
13	5.71	1169	.543	.542	850.8	4091.39	2511.41	0.00	1580.57	26228	.2883
14	5.17	842	.508	.505	944.6	2976.67	2208.71	0.00	767.97	26996	.3023
15	4.74	881	.546	.545	813.8	3084.12	2108.13	0.00	975.99	27972	.3170
16	4.95	903	.508	.498	779.8	3159.31	2229.15	0.00	930.17	28902	.3320
17	6.13	979	.447	.444	986.4	3425.29	2609.88	0.00	815.41	29718	.3483
18	4.55	742	.455	.459	745.6	2598.59	2073.72	0.00	524.87	30243	.3607
19	5.55	903	.489	.485	971.5	3161.64	2360.48	0.00	801.16	31044	.3757
20	5.46	890	.494	.478	938.0	3114.02	2343.59	0.00	770.43	31814	.3905
21	4.21	675	.500	.492	760.9	2374.09	1908.70	0.00	465.39	32280	.4017
22	5.18	837	.455	.475	893.0	2930.04	2251.77	0.00	678.27	32958	.4156
23	4.68	910	.531	.546	762.9	3184.15	2116.98	0.00	1067.17	34025	.4308
24	4.61	694	.436	.429	765.6	2430.63	2083.78	0.00	346.85	34372	.4423
25	5.35	845	.435	.431	839.2	2958.97	2362.80	0.00	596.17	34968	.4564
26	4.49	635	.467	.463	863.7	2377.21	1960.58	0.00	416.63	35385	.4670
27	3.29	412	.384	.382	590.1	1441.34	1615.13	0.00	-173.79	35211	.4738
28	3.52	538	.417	.439	591.9	1884.32	1719.69	0.00	164.62	35376	.4828
29	4.49	684	.445	.465	807.2	2395.18	2001.16	0.00	394.02	35770	.4942
30	4.99	717	.398	.406	922.0	2508.61	2215.89	0.00	292.72	36062	.5061
31	3.81	601	.482	.472	668.0	2105.06	1792.69	0.00	312.37	36375	.5161
32	4.24	499	.358	.363	903.3	1744.87	1964.91	0.00	-220.04	36155	.5244
33	4.51	630	.404	.389	730.0	2203.62	2065.84	0.00	137.78	36292	.5349
34	3.12	385	.359	.341	499.4	1345.95	1603.91	0.00	-257.97	36035	.5413
35	2.64	378	.373	.368	446.3	1324.24	1577.12	0.00	-252.89	35782	.5476
36	2.35	339	.421	.432	413.2	1186.76	1318.53	0.00	-131.77	35650	.5532
37	3.32	574	.454	.488	580.2	2008.72	1713.80	0.00	294.92	35945	.5627
38	3.71	555	.396	.420	736.0	1943.17	1999.76	0.00	-56.59	35889	.5720
39	3.00	433	.417	.426	577.3	1532.47	1643.22	0.00	-110.75	35777	.5793
40	3.07	432	.427	.440	700.3	1514.64	1739.90	0.00	-225.26	35552	.5864
41	4.76	612	.350	.367	860.5	2141.33	2235.34	0.00	-94.00	35458	.5966
42	2.76	433	.444	.465	578.6	1516.45	1609.37	0.00	-92.92	35365	.6038
43	3.12	445	.380	.394	565.7	1555.99	1706.50	0.00	-150.51	35215	.6112
44	3.14	618	.508	.525	678.2	2161.55	1936.02	0.00	225.53	35440	.6215
45	2.34	379	.385	.454	430.1	1324.90	1490.51	0.00	-165.61	35275	.6278
46	2.34	342	.409	.411	483.0	1195.90	1491.97	0.00	-295.07	34980	.6335
47	3.37	512	.443	.475	752.8	1792.89	1835.46	0.00	-42.57	34937	.6420
48	3.11	521	.459	.462	530.3	1824.13	1654.07	0.00	170.06	35107	.6507
49	5.01	716	.435	.406	994.8	2505.03	2475.88	0.00	29.15	35136	.6626
50	4.09	477	.325	.348	847.8	1669.91	2090.76	0.00	-420.85	34715	.6705
51	4.69	545	.312	.327	869.4	1907.36	2273.88	0.00	-366.51	34349	.6796
52	4.57	453	.300	.298	806.5	1584.88	2035.37	0.00	-450.49	33898	.6871
53	4.70	668	.373	.401	938.6	2336.60	2378.43	0.00	-41.83	33857	.6982
54	5.59	579	.269	.295	995.6	2023.17	2510.85	0.00	-487.67	33369	.7079
55	2.67	306	.304	.312	484.2	1070.97	1561.69	0.00	-490.72	32878	.7130

TABLE 11-11.—NETWORK MODEL RESULTS—49-SEAT 1975 AUGMENTOR WING STOL—Continued

56	3.11	409	.331	.363	597.3	1430.68	1756.98	0.00	-326.30	32552	.7198
57	3.39	366	.287	.287	515.4	1280.33	1715.63	0.00	-435.30	32117	.7258
58	2.45	232	.251	.279	456.8	812.45	1409.64	0.00	-597.19	31519	.7297
59	4.19	477	.307	.325	829.7	1669.96	2150.72	0.00	-480.76	31039	.7376
60	3.49	415	.348	.353	706.0	1451.94	1846.41	0.00	-394.47	30644	.7445
61	3.20	228	.206	.222	586.8	799.57	1578.94	0.00	-779.37	29865	.7483
62	2.39	412	.366	.366	615.4	1442.87	1869.77	0.00	-426.90	29438	.7552
63	3.97	345	.247	.251	704.9	1206.22	1914.93	0.00	-708.71	28729	.7609
64	4.17	397	.266	.262	728.1	1390.32	2064.85	0.00	-674.53	28055	.7675
65	5.55	514	.286	.269	1008.0	1797.55	2482.54	0.00	-684.99	27370	.7761
66	3.72	260	.200	.196	606.2	909.52	1796.04	0.00	-886.52	26483	.7804
67	2.37	254	.362	.324	522.3	923.80	1477.27	0.00	-553.48	25930	.7846
68	3.45	227	.204	.193	591.9	793.14	1685.17	0.00	-892.03	25038	.7884
69	2.60	274	.360	.329	611.5	1019.75	1591.39	0.00	-571.64	24466	.7930
70	1.63	198	.407	.403	417.0	750.98	1216.81	0.00	-465.83	24000	.7963
71	1.21	230	.614	.521	324.0	804.30	1169.86	0.00	-365.55	23635	.8001
72	1.48	223	.452	.456	396.8	781.54	1241.15	0.00	-459.61	23175	.8038
73	2.05	239	.299	.325	430.8	836.63	1396.52	0.00	-559.90	22615	.8078

TABLE 11-11.—NETWORK MODEL RESULTS—49-SEAT 1975 AUGMENTOR WING STOL—Concluded

DAILY SUMMARY

Mean utilization, hours	4.22
Standard deviation of utilization, hours	1.487
Distance-weighted load factor	0.447
Nonweighted load factor	0.452
Total passengers carried	48 551
Total direct operating cost, dollars	147 669.55
Total indirect operating cost, dollars	47 585.73
Total revenue, dollars	170 285.03
Total profit, dollars	-24 970.66
Mean passenger wait time, min	14.2
Total demand	60.105
Percent demand carried	80.78
Total revenue flights	2190
Total distance flown, miles	55 087
Total revenue passenger miles flown	1 135 690.
Number ferry flights	102
Total distance ferried, miles	3253.7
Profit per passenger, dollars	-0.514
Fleet size	73
Total gates required	43

TABLE 11-12.–NETWORK MODEL RESULTS–95-SEAT 1975 AUGMENTOR WING STOL

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	4.79	1564	.472	.470	777.3	5474.54	2793.84	0.00	2680.70	2681	.0260
2	4.23	1537	.507	.522	681.9	5379.09	2350.62	0.00	2828.46	5509	.0516
3	5.09	1297	.371	.379	858.1	4540.93	2891.31	0.00	1649.62	7159	.0732
4	4.41	1265	.418	.416	720.9	4428.59	2621.18	0.00	1807.41	8966	.0942
5	5.17	1514	.444	.443	886.5	5299.28	2909.64	0.00	2389.64	11356	.1194
6	4.34	1240	.417	.435	753.4	4341.73	2551.32	0.00	1790.42	13146	.1401
7	5.01	1359	.415	.409	857.1	4756.44	2845.26	0.00	1911.18	15057	.1627
8	5.71	1278	.327	.345	1001.4	4473.23	3120.00	0.00	1353.23	16411	.1839
9	5.07	1112	.323	.316	823.8	3891.66	2914.64	0.00	977.02	17388	.2024
10	5.56	1470	.371	.387	919.6	5143.69	3112.69	0.00	2031.00	19419	.2269
11	4.98	1157	.349	.338	816.8	4051.12	2864.73	0.00	1186.39	20605	.2461
12	4.78	1131	.341	.350	801.1	3959.71	2763.11	0.00	1196.60	21802	.2650
13	4.66	934	.309	.298	786.6	3269.40	2708.99	0.00	560.41	22362	.2805
14	4.06	734	.272	.276	705.4	2568.12	2430.17	0.00	137.95	22500	.2927
15	4.36	802	.297	.291	675.4	2808.63	2455.64	0.00	352.98	22853	.3061
16	5.55	1056	.276	.285	975.9	3696.39	3149.60	0.00	546.79	23400	.3236
17	3.56	693	.290	.292	606.2	2425.76	2229.73	0.00	196.03	23596	.3352
18	3.71	728	.263	.274	577.1	2546.61	2346.85	0.00	199.76	23796	.3473
19	2.53	483	.259	.283	525.0	1691.96	1995.27	0.00	-303.32	23492	.3553
20	4.52	934	.330	.317	824.7	3267.74	2688.11	0.00	579.63	24072	.3708
21	3.60	785	.298	.318	625.2	2747.37	2332.43	0.00	414.94	24487	.3839
22	4.20	724	.289	.282	785.9	2648.21	2436.04	0.00	212.17	24699	.3960
23	3.57	813	.316	.329	614.0	2846.99	2325.21	0.00	521.78	25221	.4095
24	5.39	885	.230	.252	940.7	3097.34	2990.03	0.00	107.31	25328	.4242
25	3.17	598	.253	.269	519.6	2058.48	2082.67	0.00	-24.19	25304	.4340
26	4.04	878	.316	.330	796.7	3074.08	2624.66	0.00	449.42	25753	.4486
27	4.52	914	.288	.321	886.1	3198.29	2727.68	0.00	470.61	26224	.4638
28	3.36	671	.289	.294	558.3	2348.61	2153.02	0.00	195.59	26420	.4750
29	3.72	619	.244	.241	607.5	2166.95	2320.98	0.00	-154.02	26266	.4853
30	3.46	561	.230	.227	539.3	1963.42	2231.60	0.00	-268.18	25997	.4946
31	4.35	774	.263	.263	725.6	2707.72	2578.81	0.00	128.91	26126	.5075
32	4.56	740	.230	.223	689.4	2589.81	2737.15	0.00	-147.34	25979	.5198
33	3.31	776	.264	.292	645.2	2716.38	2436.15	0.00	280.24	26259	.5327
34	3.86	652	.249	.254	659.8	2280.93	2354.72	0.00	-73.79	26185	.5435
35	4.90	835	.248	.244	797.8	2923.01	2846.04	0.00	76.97	26262	.5574
36	4.70	828	.232	.249	741.8	2897.10	2770.94	0.00	126.16	26389	.5712
37	3.16	537	.267	.257	544.7	1978.54	2053.42	0.00	-174.88	26214	.5801
38	3.98	524	.205	.204	703.5	1835.32	2382.88	0.00	-547.56	25666	.5889
39	3.61	503	.198	.204	596.9	1760.18	2268.65	0.00	-508.47	25158	.5972
40	5.45	633	.179	.180	961.8	2214.02	3003.62	0.00	-789.60	24369	.6078
41	4.13	608	.205	.221	910.8	2128.08	2679.14	0.00	-551.06	23817	.6179
42	3.61	483	.192	.198	629.2	1709.09	2335.00	0.00	-625.31	23191	.6260
43	3.32	486	.193	.189	714.8	1599.73	2435.60	0.00	-735.87	22455	.6341
44	2.41	448	.307	.295	534.9	1595.87	1910.86	0.00	-314.99	22140	.6415
45	5.15	673	.212	.192	883.7	2356.33	2998.70	0.00	-642.37	21498	.6527
46	3.10	487	.225	.223	590.8	1705.65	2264.82	0.00	-559.17	20939	.6608
47	3.99	559	.235	.210	778.6	1956.46	2612.97	0.00	-656.51	20282	.6701
48	4.39	551	.183	.187	809.4	1928.25	2723.71	0.00	-795.45	19487	.6793

TABLE 11-12.—NETWORK MODEL RESULTS—95-SEAT 1975 AUGMENTOR WING STOL—Concluded

DAILY SUMMARY

Mean utilization, hours	4.25
Standard deviation of utilization, hours	0.785
Distance-weighted load factor	0.292
Nonweighted load factor	0.297
Total passengers carried	40 830
Total direct operating cost, dollars	23 559.81
Total indirect operating cost, dollars	41 714.61
Total revenue, dollars	143 046.49
Total profit, dollars	-22 227.93
Mean passenger wait time, min	14.034
Total demand	60 105
Percent demand carried	67.93
Total revenue flights	1447
Total distance flown, miles	35 257.4
Total revenue passenger miles flown	953 405
Number ferry flights	30
Total distance ferried, miles	929.8
Profit per passenger, dollars	-0.544
Fleet size	48
Total gates required	39

TABLE 11-13.—NETWORK MODEL RESULTS—153-SEAT 1975 AUGMENTOR WING STOL

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	4.32	1711	.358	.349	686.5	5988.43	3403.59	0.00	2584.84	2585	.0285
2	4.37	1961	.389	.413	719.1	6863.36	3369.01	0.00	3494.35	6079	.0611
3	4.62	1724	.314	.331	742.9	6032.91	3572.18	0.00	2460.72	8540	.0898
4	5.32	2125	.301	.316	938.6	7435.94	4344.48	0.00	3091.46	11631	.1251
5	4.47	1530	.353	.346	799.5	5566.25	3373.42	0.00	2192.83	13824	.1516
6	4.87	1351	.257	.260	833.0	4729.27	3645.74	0.00	1083.53	14909	.1741
7	3.81	1017	.248	.256	667.9	3557.86	3020.87	0.00	536.99	15445	.1910
8	4.15	960	.215	.224	738.4	3360.08	3201.04	0.00	159.05	15604	.2069
9	4.69	1286	.241	.240	740.2	4500.59	3631.18	0.00	869.41	16473	.2283
10	4.05	1041	.237	.235	674.5	3644.00	3210.09	0.00	433.91	16907	.2457
11	4.76	1099	.210	.218	855.8	3846.97	3664.42	0.00	182.55	17090	.2639
12	4.87	970	.170	.176	776.5	3393.45	3722.13	0.00	-328.67	16761	.2801
13	3.60	933	.212	.234	624.9	3264.34	3047.05	0.00	217.29	16978	.2956
14	3.53	638	.181	.187	655.6	2407.30	2949.72	0.00	-542.41	16436	.3070
15	4.51	959	.205	.202	784.6	3356.56	3422.48	0.00	-65.92	16370	.3230
16	5.25	904	.158	.160	888.2	3162.69	3874.61	0.00	-711.92	15658	.3380
17	3.91	872	.202	.204	648.4	3051.75	3127.52	0.00	-75.76	15582	.3525
18	3.93	913	.197	.199	637.0	3196.00	3298.67	0.00	-102.68	15480	.3677
19	4.46	850	.173	.174	739.9	2975.55	3447.23	0.00	-471.67	15008	.3819
20	4.35	1118	.205	.221	857.3	3911.91	3601.11	0.00	310.80	15319	.4005
21	4.29	969	.208	.218	761.9	3391.63	3281.50	0.00	110.14	15429	.4166
22	3.93	699	.162	.163	656.4	2445.68	3134.07	0.00	-688.39	14740	.4282
23	4.33	768	.181	.179	693.8	2688.49	3164.60	0.00	-476.11	14264	.4410
24	4.97	851	.191	.186	652.6	2980.12	3253.45	0.00	-273.33	13991	.4552
25	4.38	739	.157	.156	737.8	2585.40	3384.29	0.00	-798.89	13192	.4675
26	7.37	1153	.146	.148	1276.8	4033.84	5049.43	0.00	-1015.59	12177	.4866
27	4.39	811	.169	.166	712.3	2840.05	3424.65	0.00	-584.60	11592	.5001
28	5.31	945	.155	.163	1014.7	3309.12	4284.11	0.00	-974.99	10617	.5159
29	6.22	1050	.151	.156	1041.9	3675.65	4428.88	0.00	-753.22	9864	.5333
30	5.72	944	.161	.150	950.1	3303.41	4170.08	0.00	-866.67	8997	.5490
31	6.55	962	.130	.131	1057.4	3365.48	4686.48	0.00	-1321.00	7676	.5650
32	4.13	663	.149	.144	663.6	2320.43	3262.42	0.00	-941.99	6734	.5761
33	5.13	761	.149	.142	936.7	2663.11	3852.97	0.00	-1189.86	5544	.5887
34	3.91	667	.169	.168	706.1	2335.87	3052.14	0.00	-716.27	4828	.5998

TABLE 11-13.—NETWORK MODEL RESULTS—153-SEAT 1975 AUGMENTOR WING STOL—Concluded

DAILY SUMMARY

Mean utilization, hours	4.66
Standard deviation of utilization, hours	0.867
Distance-weighted load factor	0.206
Nonweighted load factor	0.210
Total passengers carried	36 052
Total direct operating cost, dollars	121 355.59
Total indirect operating cost, dollars	40 514.08
Total revenue, dollars	126 183.49
Total profit, dollars	-35 686.17
Mean passenger wait time, min	14.448
Total demand	60 105
Percent demand carried	59.98
Total revenue flights	1124
Total distance flown, miles	26 862.9
Total revenue passenger miles flown	840 753.7
Number ferry flights	9
Total distance ferried, miles	166.6
Profit per passenger, dollars	-0.990
Fleet size	34
Total gates required	37

TABLE 11-14.—NETWORK MODEL RESULTS—50-SEAT 1975 HELICOPTER

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	7.84	1644	.646	.645	860.1	5754.56	3122.75	0.00	2531.81	2532	.0245
2	7.37	1447	.644	.643	847.2	5063.87	2920.12	0.00	2143.75	4776	.0460
3	8.84	1610	.633	.631	1056.4	5633.93	3333.48	0.00	2300.45	7076	.0699
4	7.91	1276	.598	.593	959.5	4464.44	2977.73	0.00	1486.71	8563	.0889
5	7.02	1286	.626	.647	945.4	4510.15	2760.85	0.00	1739.30	10302	.1080
6	7.79	1437	.612	.625	917.2	5028.18	3026.70	0.00	2001.39	12303	.1294
7	7.53	1302	.640	.635	930.1	4558.64	2883.28	0.00	1675.36	13979	.1488
8	6.33	1254	.634	.643	723.1	4389.12	2598.06	0.00	1791.06	15770	.1674
9	7.26	1309	.602	.609	852.8	4581.56	2863.16	0.00	1718.50	17489	.1869
10	6.05	972	.558	.572	734.0	3410.60	2463.45	0.00	947.15	18435	.2013
11	5.56	965	.585	.585	652.0	3378.38	2333.00	0.00	1045.38	19481	.2157
12	5.97	939	.533	.537	706.5	3286.54	2454.28	0.00	832.26	20313	.2297
13	5.93	966	.551	.552	697.3	3381.19	2444.54	0.00	936.65	21250	.2440
14	5.94	951	.511	.544	699.1	3329.97	2446.49	0.00	883.48	22133	.2582
15	7.29	1129	.554	.564	897.4	3949.79	2816.69	0.00	1133.10	23266	.2750
16	5.04	873	.573	.582	589.2	3054.08	2171.14	0.00	882.94	24149	.2879
17	5.05	765	.578	.567	650.3	2677.16	2173.87	0.00	503.30	24653	.2997
18	6.43	907	.489	.490	769.8	3174.55	2585.28	0.00	589.26	25242	.3128
19	6.48	816	.440	.453	791.8	2854.55	2577.43	0.00	277.12	25519	.3249
20	5.72	712	.491	.491	735.9	2490.44	2297.18	0.00	193.26	25712	.3355
21	6.49	843	.491	.496	820.4	2949.85	2545.28	0.00	404.57	26117	.3481
22	5.41	708	.441	.457	568.0	2478.68	2318.71	0.00	159.97	26277	.3586
23	5.51	892	.534	.510	615.8	3123.29	2356.98	0.00	766.31	27043	.3719
24	5.11	795	.577	.589	642.3	2782.85	2133.77	0.00	649.09	27692	.3837
25	6.68	914	.502	.494	816.9	3198.19	2635.91	0.00	562.28	28254	.3973
26	6.25	846	.499	.483	779.0	2959.28	2563.69	0.00	395.59	28650	.4099
27	6.08	789	.452	.451	727.9	2762.49	2477.37	0.00	285.12	28935	.4216
28	4.89	782	.403	.505	566.8	2737.21	2210.03	0.00	527.18	29462	.4332
29	5.21	601	.402	.401	623.6	2104.88	2208.14	0.00	-103.25	29359	.4422
30	5.40	612	.411	.422	690.8	2143.03	2248.81	0.00	-105.78	29253	.4513
31	6.10	696	.447	.435	770.5	2435.95	2428.72	0.00	7.24	29261	.4616
32	5.90	693	.407	.433	731.3	2426.93	2386.62	0.00	40.31	29301	.4720
33	5.29	656	.479	.486	678.1	2297.21	2172.22	0.00	124.99	29426	.4817
34	5.28	691	.500	.493	662.6	2417.78	2187.06	0.00	230.72	29657	.4920
35	4.98	617	.403	.426	590.3	2160.86	2172.36	0.00	-11.50	29645	.5012
36	5.10	634	.458	.453	626.6	2218.87	2148.44	0.00	70.43	29715	.5106
37	4.67	518	.427	.390	569.9	1814.23	2024.58	0.00	-210.35	29505	.5183
38	5.32	622	.497	.402	631.6	2178.67	2248.16	0.00	-69.49	29436	.5276
39	4.66	458	.381	.381	613.1	1701.30	2139.51	0.00	-438.22	28997	.5344
40	4.95	497	.378	.382	625.3	1738.80	2084.06	0.00	-345.26	28652	.5418
41	3.66	429	.417	.390	425.8	1501.83	1744.02	0.00	-242.19	28410	.5481
42	4.59	531	.405	.370	547.5	1857.29	2094.93	0.00	-237.64	28172	.5560
43	4.34	530	.416	.424	537.5	1853.49	1989.75	0.00	-136.26	28036	.5639
44	3.48	396	.358	.396	416.3	1387.50	1670.85	0.00	-283.35	27753	.5698
45	4.59	429	.362	.356	600.4	1501.73	2025.91	0.00	-524.18	27229	.5762
46	6.63	611	.357	.349	853.4	2140.18	2643.64	0.00	-503.46	26725	.5853
47	4.83	598	.465	.478	691.7	2093.42	2249.79	0.00	-156.37	26569	.5942
48	5.84	498	.378	.344	797.3	1743.50	2426.02	0.00	-682.52	25886	.6016
49	6.68	689	.356	.363	862.6	2411.10	2810.83	0.00	-399.73	25486	.6118
50	5.91	667	.404	.430	844.0	2335.18	2633.48	0.00	-298.30	25188	.6218
51	2.60	290	.411	.414	381.7	1014.16	1539.38	0.00	-525.22	24663	.6261
52	3.26	252	.312	.315	426.8	880.91	1556.28	0.00	-675.37	23988	.6298
53	5.02	480	.386	.369	637.7	1678.79	2097.44	0.00	-418.65	23569	.6370
54	2.43	250	.296	.357	329.6	873.47	1451.94	0.00	-578.48	22990	.6407
55	2.62	390	.376	.459	345.5	1365.54	1594.88	0.00	-229.35	22761	.6465

TABLE 11-14.—NETWORK MODEL RESULTS—50-SEAT 1975 HELICOPTER—Continued

56	6.16	647	.365	.381	794.4	2265.54	2580.22	0.00	-314.68	22346	.6561
57	6.45	524	.293	.290	817.5	1933.85	2605.08	0.00	-671.23	21675	.6639
58	3.59	390	.371	.390	476.8	1395.52	1797.77	0.00	-402.25	21273	.6698
59	3.48	367	.312	.350	422.5	1285.59	1740.48	0.00	-454.89	20818	.6753
60	2.57	327	.458	.435	362.3	1143.00	1550.01	0.00	-407.01	20411	.6801
61	2.98	352	.416	.391	384.8	1271.89	1677.03	0.00	-405.14	20006	.6854
62	4.48	402	.326	.321	585.4	1405.49	1972.74	0.00	-567.26	19439	.6914
63	6.16	649	.341	.392	795.2	2271.78	2581.13	0.00	-309.35	19129	.7010
64	5.59	449	.287	.309	749.7	1470.40	2374.94	0.00	-904.54	18225	.7077
65	4.55	378	.274	.291	547.3	1322.29	2000.31	0.00	-678.02	17547	.7133
66	5.34	391	.253	.270	660.4	1369.52	2216.17	0.00	-846.65	16700	.7191
67	4.77	372	.264	.266	583.0	1301.74	2133.04	0.00	-831.30	15869	.7247
68	3.88	278	.255	.278	513.0	971.28	1806.24	0.00	-834.96	15034	.7288
69	4.23	351	.265	.280	515.9	1225.91	1965.65	0.00	-739.75	14294	.7340
70	4.92	445	.285	.307	598.0	1556.21	2180.65	0.00	-624.43	13670	.7406
71	3.90	287	.244	.250	478.8	1005.09	1895.31	0.00	-889.21	12780	.7449
72	4.03	351	.281	.334	568.9	1227.83	1960.57	0.00	-732.74	12048	.7501
73	3.58	232	.231	.232	454.9	811.41	1743.82	0.00	-932.41	11115	.7536
74	5.06	370	.239	.264	638.7	1205.12	2102.83	0.00	-897.71	10218	.7591
75	2.58	221	.281	.295	345.0	774.95	1499.97	0.00	-725.03	9493	.7624
76	2.34	253	.306	.317	305.0	887.03	1519.95	0.00	-632.92	8860	.7661
77	4.60	333	.290	.303	645.6	1166.71	2044.01	0.00	-877.31	7982	.7711
78	5.25	363	.246	.260	714.8	1272.11	2337.52	0.00	-1065.41	6917	.7765
79	3.23	280	.339	.329	465.7	978.56	1723.91	0.00	-745.26	6172	.7806

TABLE 11-14.—NETWORK MODEL RESULTS—50-SEAT 1975 HELICOPTER—Concluded

DAILY SUMMARY

Mean utilization, hours	5.22
Standard deviation of utilization, hours	1.425
Distance-weighted load factor	0.442
Nonweighted load factor	0.453
Total passengers carried	52 483
Total direct operating cost, dollars	177 520.49
Total indirect operating cost, dollars	48 865.70
Total revenue, dollars	183 692.12
Total profit, dollars	-42 694.07
Mean passenger wait time, min	14.197
Total demand	67 231.0
Percent demand carried	78.06
Total revenue flights	2319
Total distance flown, miles	51 489.3
Total revenue passenger miles flown	1 105 391.4
Number ferry flights	73
Total distance ferried, miles	1415.9
Profit per passenger, dollars	-0.813
Fleet size	79
Total gates required	49

TABLE 11-15.—NETWORK MODEL RESULTS—98-SEAT 1975 HELICOPTER

FLIGHT STATISTICS

FLT NBR	HRS UTIL	FAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	4.76	1451	.499	.493	545.4	5077.61	3007.01	0.00	2170.60	2171	.0216
2	5.40	1468	.431	.428	605.5	5138.19	3323.59	0.00	1714.60	3885	.0434
3	6.23	1483	.422	.420	757.5	5192.05	3593.21	0.00	1598.86	5484	.0655
4	6.48	1533	.389	.401	766.8	5365.65	3743.59	0.00	1622.07	7106	.0883
5	5.95	1379	.393	.380	687.7	4824.96	3535.85	0.00	1289.12	8395	.1088
6	5.97	1467	.376	.394	679.1	5134.84	3568.79	0.00	1566.05	9961	.1306
7	5.32	1139	.375	.363	629.9	3985.23	3222.77	0.00	762.45	10724	.1475
8	5.68	1313	.369	.393	660.7	4595.29	3404.82	0.00	1190.47	11914	.1671
9	4.74	977	.388	.384	594.6	3420.47	2897.10	0.00	523.36	12438	.1816
10	7.38	1336	.313	.317	891.8	4677.47	4110.25	0.00	567.22	13005	.2015
11	4.95	978	.362	.356	608.4	3423.62	3008.69	0.00	414.94	13420	.2160
12	5.51	981	.295	.303	654.9	3433.60	3305.13	0.00	128.47	13548	.2306
13	5.39	913	.354	.345	709.2	3195.36	3111.67	0.00	83.69	13632	.2442
14	5.20	871	.308	.296	631.4	3047.10	3133.75	0.00	-86.64	13545	.2572
15	4.70	941	.334	.331	547.6	3294.81	2964.71	0.00	330.10	13875	.2712
16	4.04	531	.290	.285	548.4	1927.02	2509.98	0.00	-582.96	13292	.2791
17	5.56	951	.317	.316	689.5	3365.01	3264.99	0.00	100.02	13392	.2934
18	4.58	926	.301	.326	523.6	3240.30	2929.31	0.00	310.99	13703	.3071
19	5.19	814	.242	.268	616.3	2851.39	3157.03	0.00	-305.64	13397	.3192
20	6.00	761	.270	.243	764.8	2665.21	3421.98	0.00	-756.77	12640	.3306
21	4.99	698	.289	.264	630.9	2441.51	2996.18	0.00	-554.67	12085	.3409
22	4.65	694	.253	.272	576.5	2428.53	2870.44	0.00	-441.91	11644	.3513
23	3.95	408	.208	.221	477.2	1742.34	2587.40	0.00	-845.06	10799	.3587
24	6.64	942	.256	.260	825.5	3295.69	3738.87	0.00	-443.18	10356	.3727
25	3.56	580	.313	.329	467.0	2028.76	2344.35	0.00	-315.59	10040	.3813
26	3.63	547	.255	.279	494.2	1915.85	2566.76	0.00	-650.91	9389	.3894
27	2.79	476	.291	.256	301.3	1666.40	2145.77	0.00	-479.37	8910	.3965
28	4.51	693	.260	.253	523.0	2426.26	2882.77	0.00	-456.51	8453	.4068
29	3.86	676	.286	.288	466.6	2366.83	2662.87	0.00	-296.04	8157	.4169
30	4.17	608	.257	.270	520.7	2127.46	2651.51	0.00	-524.05	7633	.4259
31	3.78	658	.274	.305	476.6	2304.22	2586.44	0.00	-282.22	7351	.4357
32	4.61	683	.263	.268	560.3	2392.16	2859.85	0.00	-467.69	6883	.4459
33	5.66	714	.245	.251	736.3	2497.80	3242.74	0.00	-744.94	6138	.4565
34	4.98	668	.274	.273	655.1	2338.92	2940.79	0.00	-601.87	5536	.4664
35	4.75	577	.233	.236	605.9	2020.33	2872.69	0.00	-852.37	4684	.4750
36	5.67	837	.264	.259	686.1	2928.68	3351.14	0.00	-422.46	4262	.4875
37	6.08	725	.214	.224	765.8	2537.91	3468.65	0.00	-930.74	3331	.4983
38	4.51	553	.225	.235	574.1	1934.78	2775.83	0.00	-841.05	2490	.5065
39	4.06	478	.278	.232	525.6	1673.25	2567.47	0.00	-894.22	1596	.5136
40	3.50	471	.239	.229	415.7	1649.46	2405.54	0.00	-756.09	839	.5206
41	5.83	625	.201	.206	744.0	2187.56	3345.34	0.00	-1157.78	-318	.5299
42	5.20	557	.196	.203	717.3	1948.61	3305.96	0.00	-1357.35	-1676	.5382
43	6.16	762	.209	.210	729.1	2668.30	3596.82	0.00	-928.52	-2604	.5495
44	4.22	547	.227	.223	504.3	1914.50	2718.48	0.00	-803.98	-3408	.5577
45	4.08	684	.281	.304	562.6	2395.63	2849.96	0.00	-454.33	-3863	.5678
46	5.18	677	.217	.223	635.6	2370.52	3231.17	0.00	-860.65	-4723	.5779
47	4.83	676	.251	.255	590.2	2366.15	2949.55	0.00	-583.40	-5307	.5880
48	3.37	466	.216	.250	415.2	1629.39	2313.55	0.00	-684.16	-5991	.5949
49	5.09	510	.169	.179	663.3	1784.61	3226.38	0.00	-1441.77	-7432	.6025
50	6.73	752	.215	.197	816.8	2630.38	3817.37	0.00	-1186.99	-8619	.6137
51	3.83	437	.195	.212	500.6	1529.89	2576.21	0.00	-1046.32	-9666	.6202
52	4.91	611	.191	.238	574.6	2137.88	3050.02	0.00	-912.14	-10578	.6292
53	4.89	482	.171	.192	609.9	1686.87	2965.15	0.00	-1278.28	-11856	.6364
54	3.90	445	.186	.206	480.9	1557.08	2547.23	0.00	-990.15	-12846	.6430
55	4.66	520	.207	.204	618.1	1819.22	3022.90	0.00	-1203.67	-14050	.6508

TABLE 11-15.–NETWORK MODEL RESULTS–98-SEAT 1975 HELICOPTER–Continued

56	3.18	429	.259	.230	377.5	15[illegible]1.56	2258.02	0.00	-756.45	-14806	.6571
57	4.32	562	.249	.239	577.2	19[illegible]5.62	2871.47	0.00	-935.84	-15712	.6655
58	3.85	446	.226	.217	503.1	15[illegible]1.68	2579.89	0.00	-1118.20	-15731	.6721
59	4.85	592	.221	.201	582.1	2070.44	3106.75	0.00	-1036.31	-17767	.6809
60	7.34	596	.151	.160	949.8	20[illegible]5.40	3967.79	0.00	-1381.38	-19648	.6898
61	4.76	401	.152	.151	585.1	1412.86	2928.71	0.00	-1525.85	-21174	.6958

TABLE 11-15.—NETWORK MODEL RESULTS—98-SEAT 1975 HELICOPTER—Concluded

DAILY SUMMARY

Mean utilization, hours	4.93
Standard deviation of utilization, hours	0.995
Distance-weighted load factor	0.272
Nonweighted load factor	0.278
Total passengers carried	46 777
Total direct operating cost, dollars	184 960.54
Total indirect operating cost, dollars	46 526.56
Total revenue, dollars	163 786.46
Total profit, dollars	-67 700.63
Mean passenger wait time, min	14.385
Total demand	67 231.0
Percent demand carried	69.58
Total revenue flights	1718
Total distance flown, miles	37 155.8
Total revenue passenger miles flown	979 713.4
Number ferry flights	20
Total distance ferried, miles	336.4
Profit per passenger, dollars	1.447
Fleet size	61
Total gates required	45

TABLE 11-16.—NETWORK MODEL RESULTS—150-SEAT 1975 HELICOPTER

FLIGHT STATISTICS

FLT NOR	HRS UTIL	FAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	5.03	1800	.384	.375	577.3	6300.72	3918.36	0.00	2382.37	2382	.0268
2	5.57	1538	.315	.320	684.7	5381.46	4114.33	0.00	1267.17	3650	.0496
3	5.66	1609	.293	.306	663.1	5630.10	4246.75	0.00	1383.35	5033	.0736
4	5.53	1577	.295	.309	650.6	5519.59	4166.68	0.00	1352.91	6386	.0970
5	5.59	1250	.245	.245	661.7	4375.57	4186.90	0.00	188.67	6574	.1156
6	5.48	1348	.276	.290	680.0	4718.74	4048.32	0.00	670.42	7245	.1357
7	4.69	1205	.269	.277	540.1	4218.21	3695.01	0.00	523.20	7768	.1536
8	4.57	1294	.295	.297	525.4	4529.23	3651.86	0.00	877.37	8645	.1729
9	5.43	1079	.236	.240	687.6	3777.36	3997.52	0.00	-220.16	8425	.1889
10	4.28	1073	.249	.265	494.0	3755.88	3479.79	0.00	276.09	8701	.2049
11	5.18	1051	.265	.242	646.5	3679.54	3872.55	0.00	-193.02	8508	.2205
12	5.54	1187	.252	.255	692.3	4153.14	4070.75	0.00	82.39	8591	.2382
13	4.11	759	.215	.211	499.6	2657.00	3318.39	0.00	-661.39	7930	.2494
14	4.33	770	.182	.190	504.7	2695.89	3499.41	0.00	-803.52	7126	.2609
15	5.62	1275	.269	.258	681.2	4462.24	4165.16	0.00	297.08	7423	.2799
16	4.11	797	.230	.221	499.8	2790.35	3318.43	0.00	-528.08	6895	.2917
17	5.47	1207	.259	.252	664.7	4225.27	4077.66	0.00	147.61	7043	.3097
18	5.54	942	.202	.196	679.3	3298.04	4104.28	0.00	-806.24	6236	.3237
19	6.46	1131	.206	.215	823.2	3957.07	4538.76	0.00	-581.69	5655	.3405
20	5.27	896	.212	.213	677.6	3135.24	3871.99	0.00	-736.75	4918	.3538
21	5.99	955	.173	.182	728.2	3343.04	4365.55	0.00	-1022.51	3896	.3680
22	7.24	1024	.158	.166	897.5	3582.26	5018.13	0.00	-1435.87	2460	.3833
23	2.75	710	.221	.263	309.7	2483.94	2627.99	0.00	-144.05	2316	.3938
24	5.34	645	.132	.134	639.0	2257.72	4029.04	0.00	-1771.31	544	.4034
25	4.73	708	.187	.189	630.9	2478.27	3672.13	0.00	-1193.86	-650	.4139
26	6.21	855	.162	.158	759.4	2992.62	4479.72	0.00	-1487.10	-2137	.4287
27	7.41	1184	.161	.175	879.3	4145.36	5214.24	0.00	-1068.88	-3206	.4443
28	6.44	885	.154	.155	777.4	3096.72	4627.20	0.00	-1530.48	-4736	.4574
29	5.74	881	.166	.173	692.0	3084.17	4242.20	0.00	-1158.03	-5894	.4706
30	4.60	679	.177	.181	625.1	2375.37	3718.90	0.00	-1343.53	-7238	.4806
31	5.70	762	.151	.154	717.6	2667.59	4288.82	0.00	-1621.22	-8859	.4920
32	4.43	645	.183	.172	550.6	2259.18	3468.47	0.00	-1209.29	-10068	.5016
33	5.77	797	.154	.161	712.2	2789.38	4221.71	0.00	-1432.33	-11500	.5134
34	4.94	611	.146	.151	626.1	2139.86	3720.67	0.00	-1580.81	-13081	.5225
35	4.17	607	.141	.156	484.8	2123.97	3405.93	0.00	-1281.95	-14363	.5316
36	7.62	925	.148	.150	974.4	3237.87	5158.42	0.00	-1920.55	-16284	.5453
37	5.30	643	.146	.138	643.5	2250.11	3981.84	0.00	-1731.73	-18015	.5549
38	6.12	780	.169	.162	794.8	2728.40	4314.94	0.00	-1586.54	-19602	.5665

TABLE 11-16.—NETWORK MODEL RESULTS—150-SEAT 1975 HELICOPTER—Concluded

DAILY SUMMARY

Mean utilization, hours	5.37
Standard deviation of utilization, hours	0.966
Distance-weighted load factor	0.209
Nonweighted load factor	0.214
Total passengers carried	38 085
Total direct operating cost, dollars	152 898.28
Total indirect operating cost, dollars	40 482.05
Total revenue, dollars	133 296.27
Total profit, dollars	-60 084.06
Mean passenger wait time, min	14.115
Total demand	67 231.0
Percent demand carried	56.65
Total revenue flights	1185
Total distance flown, miles	24 980.0
Total revenue passenger miles flown	781 611.3
Number ferry flights	4
Total distance ferried, miles	40.2
Profit per passenger, dollars	1.578
Fleet size	38
Total gates required	36

TABLE 11-17.—NETWORK MODEL RESULTS—49-SEAT 1985 AUGMENTOR WING STOL

FLIGHT STATISTICS

FLT NPR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	7.90	1989	.665	.676	1217.1	6960.49	2862.49	0.00	4198.01	4198	.0206
2	7.94	1738	.649	.645	1376.3	6082.57	2784.70	0.00	3297.96	7396	.0386
3	7.98	1768	.658	.656	1391.8	6189.24	2791.49	0.00	3397.76	10794	.0569
4	7.08	1578	.638	.644	1202.1	5522.90	2561.36	0.00	2961.84	13756	.0732
5	6.98	1467	.604	.611	1192.3	5133.30	2527.25	0.00	2606.05	16362	.0884
6	8.21	2019	.669	.675	1304.5	7266.48	3130.25	0.00	4136.23	20499	.1093
7	7.97	1841	.704	.696	1415.2	6442.82	2772.25	0.00	3670.57	24168	.1283
8	7.30	1615	.687	.697	1340.3	5712.66	2562.53	0.00	3150.13	27319	.1450
9	7.51	1664	.697	.679	1361.0	5843.94	2630.56	0.00	3213.38	30532	.1622
10	6.76	1657	.702	.704	1139.9	5798.64	2474.85	0.00	3323.80	33856	.1794
11	6.84	1522	.648	.647	1168.3	5325.77	2487.26	0.00	2838.52	36694	.1951
12	6.39	1491	.641	.661	1058.2	5217.77	2380.14	0.00	2837.63	39532	.2105
13	6.45	1393	.641	.632	1108.3	4876.21	2372.57	0.00	2503.64	42036	.2250
14	6.52	1476	.668	.655	1107.9	5166.53	2401.85	0.00	2764.68	44800	.2402
15	6.05	1231	.597	.598	1045.7	4317.58	2256.69	0.00	2060.89	46861	.2530
16	5.40	1201	.629	.628	892.5	4212.96	2101.18	0.00	2111.78	48973	.2654
17	5.10	1076	.612	.610	864.1	3767.64	2000.31	0.00	1767.33	50721	.2765
18	4.93	1026	.606	.598	831.4	3590.57	1956.51	0.00	1634.06	52354	.2872
19	5.36	1204	.646	.614	845.3	4214.77	2110.05	0.00	2104.72	54459	.2996
20	5.76	1233	.637	.629	997.8	4316.73	2176.76	0.00	2139.97	56599	.3124
21	5.10	967	.570	.564	893.7	3383.70	1983.76	0.00	1399.95	57999	.3224
22	5.81	1124	.571	.559	984.5	3934.12	2200.44	0.00	1733.68	59733	.3340
23	4.60	738	.452	.456	763.7	2583.41	1867.91	0.00	715.50	60449	.3417
24	5.04	895	.521	.522	871.9	3133.92	1974.24	0.00	1159.68	61608	.3509
25	5.19	1020	.548	.548	839.5	3568.89	2048.54	0.00	1520.35	63129	.3615
26	4.58	794	.470	.477	728.2	2780.63	1881.88	0.00	898.74	64027	.3697
27	4.39	777	.530	.547	800.8	2720.32	1766.19	0.00	954.14	64981	.3777
28	5.75	1188	.575	.577	934.0	4156.64	2207.81	0.00	1948.83	66930	.3900
29	5.75	1062	.568	.556	1022.1	3718.25	2157.90	0.00	1560.35	68490	.4010
30	4.67	870	.573	.555	819.5	3043.62	1862.39	0.00	1181.22	69671	.4100
31	5.26	962	.542	.531	895.7	3367.45	2043.63	0.00	1323.83	70995	.4200
32	4.36	749	.513	.478	704.7	2623.08	1812.61	0.00	810.49	71806	.4277
33	4.82	911	.560	.531	788.0	3188.75	1937.52	0.00	1251.23	73057	.4371
34	3.82	629	.481	.475	646.8	2200.67	1639.85	0.00	560.82	73618	.4437
35	4.31	758	.502	.499	713.9	2653.77	1787.16	0.00	866.61	74484	.4515
36	5.66	1008	.494	.490	902.7	3528.42	2194.13	0.00	1334.29	75819	.4619
37	4.71	851	.483	.496	747.6	2978.90	1919.84	0.00	1059.07	76878	.4707
38	4.09	745	.568	.543	752.5	2609.09	1745.06	0.00	864.03	77742	.4785
39	4.99	853	.543	.544	1004.8	3089.55	2002.89	0.00	1086.66	78828	.4873
40	3.91	638	.495	.465	685.4	2232.51	1715.68	0.00	516.83	79345	.4939
41	2.92	555	.545	.515	489.4	1942.40	1452.99	0.00	489.41	79835	.4996
42	6.12	1012	.473	.480	1042.2	3540.93	2284.65	0.00	1256.27	81091	.5101
43	3.68	613	.493	.521	713.7	2146.37	1610.12	0.00	536.26	81627	.5164
44	4.77	676	.436	.418	829.3	2367.37	1896.61	0.00	470.77	82098	.5234
45	5.15	753	.474	.452	942.7	2718.55	1975.72	0.00	742.84	82841	.5312
46	5.36	887	.471	.464	874.7	3104.75	2093.41	0.00	1011.35	83852	.5404
47	4.32	656	.448	.446	779.5	2295.16	1915.85	0.00	479.31	84331	.5472
48	4.65	692	.434	.441	914.0	2421.74	1992.64	0.00	429.09	84761	.5544
49	3.26	463	.415	.411	552.6	1621.90	1480.66	0.00	141.24	84902	.5592
50	3.65	586	.462	.479	642.0	2052.49	1578.73	0.00	473.76	85376	.5652
51	3.14	526	.453	.488	638.6	1842.41	1577.25	0.00	265.16	85641	.5707
52	3.14	526	.513	.511	697.8	1881.30	1603.17	0.00	278.13	85919	.5761
53	6.05	764	.368	.371	1147.5	2673.71	2389.70	0.00	284.01	86203	.5840
54	2.98	453	.484	.420	546.4	1586.00	1507.41	0.00	78.59	86281	.5887
55	3.14	463	.428	.430	671.2	1620.67	1621.03	0.00	-.36	86281	.5935

TABLE 11-17.–NETWORK MODEL RESULTS–49-SEAT 1985 AUGMENTOR WING STOL–Continued

56	3.17	480	.502	.499	672.1	1791.59	1503.43	0.00	288.17	86569	.5985
57	2.65	400	.410	.430	509.3	1400.43	1402.73	0.00	-2.31	86567	.6026
58	2.47	353	.467	.424	466.6	1252.75	1295.57	0.00	-42.82	86524	.6062
59	2.40	454	.574	.545	538.2	1588.72	1415.38	0.00	173.35	86697	.6109
60	3.28	458	.420	.407	560.1	1604.62	1483.94	0.00	120.68	86818	.6157
61	3.27	547	.462	.465	595.3	1914.20	1587.82	0.00	326.38	87144	.6213
62	3.28	458	.442	.445	651.4	1657.49	1494.37	0.00	163.11	87308	.6261
63	4.71	629	.402	.401	901.5	2203.01	1957.69	0.00	245.32	87553	.6326
64	4.21	629	.423	.443	869.9	2202.43	1913.93	0.00	288.50	87841	.6391
65	2.30	426	.525	.512	433.0	1491.32	1310.38	0.00	180.94	88022	.6435
66	3.04	507	.428	.450	539.9	1775.49	1534.06	0.00	241.43	88264	.6488
67	5.48	924	.430	.460	1095.5	3234.93	2455.44	0.00	779.49	89043	.6583
68	6.30	786	.338	.349	1126.0	2752.51	2498.25	0.00	254.25	89297	.6665
69	3.96	628	.448	.457	836.6	2196.40	1899.79	0.00	296.62	89594	.6730
70	5.20	696	.347	.347	757.8	2437.03	2101.27	0.00	335.76	89930	.6802
71	5.66	806	.425	.422	1122.3	2820.73	2319.70	0.00	501.03	90431	.6885
72	2.93	468	.521	.503	607.0	1647.55	1474.99	0.00	172.56	90603	.6934
73	3.91	613	.466	.431	856.7	2144.57	1997.07	0.00	147.50	90751	.6997
74	3.51	420	.377	.343	657.2	1471.36	1644.40	0.00	-173.04	90578	.7040
75	4.42	512	.369	.360	944.5	1834.99	1947.02	0.00	-112.03	90466	.7093
76	3.50	444	.390	.378	748.9	1554.06	1714.00	0.00	-159.95	90306	.7139
77	3.30	517	.464	.479	797.2	1808.86	1735.11	0.00	73.75	90380	.7193
78	5.85	740	.342	.351	1075.4	2591.35	2417.15	0.00	174.19	90554	.7269
79	3.85	460	.329	.348	725.0	1611.05	1733.04	0.00	-121.99	90432	.7317
80	4.36	435	.296	.296	827.0	1523.48	1866.10	0.00	-342.62	90089	.7362
81	5.11	509	.271	.289	900.8	1782.94	2045.86	0.00	-262.92	89826	.7415
82	4.19	414	.318	.302	755.6	1477.49	1716.90	0.00	-239.41	89587	.7458
83	3.94	359	.230	.252	639.2	1254.31	1780.73	0.00	-526.42	89060	.7495
84	4.40	376	.245	.248	748.1	1317.37	1802.12	0.00	-484.75	88576	.7534
85	4.15	315	.236	.230	740.6	1103.05	1710.36	0.00	-607.32	87968	.7566
86	4.28	400	.270	.272	764.1	1399.53	1809.10	0.00	-409.57	87559	.7608
87	3.41	259	.210	.241	569.4	908.14	1531.76	0.00	-623.62	86935	.7635
88	4.60	431	.237	.258	770.1	1507.15	1929.67	0.00	-422.53	86513	.7679
89	4.23	308	.243	.225	772.2	1129.35	1724.16	0.00	-594.82	85919	.7711
90	3.73	313	.207	.228	584.8	1095.37	1642.19	0.00	-546.83	85371	.7743
91	2.61	214	.219	.219	465.4	750.60	1413.02	0.00	-662.42	84709	.7766
92	2.75	224	.226	.229	493.5	784.41	1391.43	0.00	-607.02	84102	.7789
93	3.63	278	.207	.210	610.6	974.40	1653.49	0.00	-679.07	83423	.7818
94	2.33	211	.233	.270	473.8	739.79	1298.74	0.00	-558.95	82864	.7840
95	2.74	199	.225	.213	509.4	695.53	1373.30	0.00	-677.79	82186	.7860
96	1.78	231	.294	.363	424.6	808.83	1247.73	0.00	-438.91	81747	.7884
97	2.04	296	.318	.402	461.3	1035.15	1322.75	0.00	-287.60	81459	.7915
98	2.04	292	.344	.397	461.5	1021.78	1322.83	0.00	-301.05	81158	.7945
99	1.31	215	.466	.498	329.5	760.40	1058.67	0.00	-298.27	80860	.7967
100	2.52	251	.303	.285	553.1	879.29	1451.39	0.00	-572.10	80288	.7993
101	1.43	197	.458	.446	373.8	737.18	1078.02	0.00	-340.84	79947	.8013
102	1.51	204	.449	.462	435.8	829.09	1134.64	0.00	-305.55	79641	.8034
103	1.92	248	.463	.389	476.6	931.85	1270.46	0.00	-338.61	79303	.8060
104	1.67	222	.414	.377	442.3	788.92	1255.44	0.00	-466.52	78836	.8083
105	2.04	270	.387	.393	523.0	944.88	1349.75	0.00	-404.87	78431	.8111
106	1.80	233	.385	.396	527.0	814.17	1322.02	0.00	-507.85	77924	.8135
107	3.89	362	.281	.264	810.4	1267.61	1888.33	0.00	-620.72	77303	.8173
108	1.73	227	.357	.395	467.0	792.78	1266.25	0.00	-473.47	76829	.8196
109	1.49	237	.430	.440	372.1	829.38	1165.76	0.00	-336.38	76493	.8220
110	1.24	211	.386	.478	436.6	737.62	1223.49	0.00	-485.85	76007	.8242

TABLE 11-17.—NETWORK MODEL RESULTS—49-SEAT 1985 AUGMENTOR WING STOL—*Concluded*

DAILY SUMMARY

Mean utilization, hours	4.32
Standard deviation of utilization, hours	1.688
Distance-weighted load factor	0.487
Nonweighted load factor	0.486
Total passengers carried	79 653
Total direct operating cost, dollars	203 653.10
Total indirect operating cost, dollars	63 051.60
Total revenue, dollars	279 660.31
Total profit, dollars	12 955.61
Mean passenger wait time, min	13.983
Total demand	96 640.0
Percent demand carried	82.42
Total revenue flights	3346
Total distance flown, miles	86 796.2
Total revenue passenger miles flown	1 936 921.6
Number ferry flights	181
Total distance ferried, miles	5636.4
Profit per passenger, dollars	0.163
Fleet size	110
Total gates required	64

TABLE 11-18.—NETWORK MODEL RESULTS—95-SEAT 1985 AUGMENTOR WING STOL

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C. PCNT
1	6.05	1930	.489	.495	1074.5	6754.19	2877.04	0.00	3377.15	3877	.0200
2	5.58	2312	.559	.579	870.2	8090.79	2807.44	0.00	5287.33	9164	.0439
3	6.49	2376	.554	.556	1123.0	8314.66	3058.39	0.00	5256.27	14421	.0685
4	4.57	1745	.552	.557	754.2	6108.24	2391.58	0.00	3716.65	18137	.0865
5	4.77	1479	.487	.497	856.4	5177.79	2409.05	0.00	2768.72	20906	.1018
6	5.72	1957	.507	.515	981.1	6848.14	2787.05	0.00	4061.09	24967	.1221
7	4.78	1651	.517	.527	832.0	5778.20	2434.31	0.00	3343.89	28311	.1392
8	5.70	1689	.469	.444	974.4	5910.49	2783.34	0.00	3127.15	31438	.1566
9	5.53	1624	.446	.450	968.3	5685.46	2702.65	0.00	2982.81	34421	.1735
10	4.90	1444	.464	.447	883.0	5053.17	2501.03	0.00	2552.15	36973	.1884
11	5.76	1521	.430	.410	1024.3	5340.46	2772.08	0.00	2568.38	39542	.2041
12	4.01	1109	.402	.417	687.9	3880.58	2161.74	0.00	1718.84	41260	.2156
13	4.00	1053	.374	.382	655.3	3686.27	2182.52	0.00	1503.75	42764	.2265
14	2.82	803	.457	.445	539.1	2809.90	1770.55	0.00	1039.35	43804	.2348
15	4.96	1176	.396	.387	928.8	4291.64	2448.88	0.00	1842.77	45646	.2470
16	3.77	909	.413	.390	712.8	3380.71	2020.73	0.00	1359.98	47006	.2564
17	4.85	1263	.391	.391	829.9	4419.52	2471.84	0.00	1947.69	48954	.2694
18	5.09	1108	.341	.324	862.2	3878.35	2566.99	0.00	1311.36	50265	.2809
19	4.34	976	.326	.321	697.4	3415.41	2321.68	0.00	1093.73	51359	.2910
20	4.49	1003	.310	.330	752.6	3511.39	2352.03	0.00	1159.96	52519	.3014
21	4.91	1227	.387	.391	879.7	4293.29	2460.35	0.00	1832.93	54352	.3141
22	5.51	1113	.289	.293	935.9	3895.64	2809.86	0.00	1094.77	55447	.3256
23	4.30	1077	.409	.391	833.2	3788.52	2357.63	0.00	1430.83	56878	.3367
24	5.52	1044	.280	.289	998.5	3653.98	2757.91	0.00	896.06	57774	.3475
25	4.28	872	.296	.296	738.0	3052.13	2343.93	0.00	708.15	58482	.3566
26	4.40	1093	.358	.371	849.0	3825.68	2482.33	0.00	1343.35	59825	.3679
27	4.65	1045	.334	.324	823.3	3657.75	2545.57	0.00	1112.18	60937	.3787
28	3.38	750	.319	.316	575.1	2625.26	2022.38	0.00	602.88	61540	.3865
29	4.68	1106	.357	.364	824.2	3870.43	2391.35	0.00	1479.09	63019	.3979
30	3.55	649	.272	.273	602.6	2271.05	1998.83	0.00	272.22	63292	.4046
31	4.71	945	.288	.293	777.7	3309.24	2443.19	0.00	866.05	64158	.4144
32	4.42	1149	.359	.366	830.7	4020.28	2588.33	0.00	1431.95	65590	.4263
33	5.10	989	.296	.289	864.9	3462.15	2568.44	0.00	893.71	66483	.4365
34	3.98	766	.294	.298	712.7	2681.22	2214.08	0.00	467.14	66950	.4444
35	2.81	629	.331	.331	538.7	2202.40	1847.65	0.00	354.76	67305	.4510
36	4.77	897	.291	.286	826.6	3139.45	2431.35	0.00	708.10	68013	.4602
37	5.50	995	.262	.276	959.5	3483.68	2697.24	0.00	786.44	68800	.4705
38	3.53	812	.364	.329	701.5	2842.57	2246.57	0.00	596.00	69396	.4789
39	5.70	1055	.283	.271	980.1	3691.03	2863.85	0.00	827.19	70223	.4899
40	6.07	1054	.272	.258	1026.1	3689.41	2927.81	0.00	761.60	70984	.5108
41	5.54	989	.263	.260	914.5	3460.94	2750.44	0.00	710.49	71695	.5110
42	3.67	713	.292	.289	620.8	2495.30	2047.50	0.00	447.79	72143	.5184
43	4.20	829	.285	.291	801.3	2900.68	2417.45	0.00	483.24	72626	.5269
44	4.06	720	.253	.261	680.3	2519.96	2196.23	0.00	323.72	72950	.5344
45	4.01	649	.235	.235	660.9	2270.11	2185.60	0.00	84.51	73034	.5411
46	4.25	742	.272	.269	783.6	2596.33	2291.70	0.00	304.63	73339	.5488
47	4.38	756	.266	.257	741.3	2646.31	2307.11	0.00	339.20	73678	.5566
48	4.17	813	.274	.268	634.0	2847.15	2286.84	0.00	560.31	74238	.5650
49	3.54	666	.275	.270	572.1	2331.79	2020.76	0.00	311.01	74549	.5719
50	6.40	925	.216	.216	1089.1	3236.30	3039.81	0.00	196.49	74746	.5815
51	5.26	691	.196	.191	867.5	2418.85	2647.23	0.00	-228.38	74517	.5886
52	4.35	951	.319	.303	737.7	3327.78	2459.89	0.00	867.88	75385	.5985
53	4.30	601	.224	.218	801.2	2103.95	2301.33	0.00	-197.43	75188	.6047
54	5.06	610	.188	.186	946.3	2165.39	2651.85	0.00	-486.46	74701	.6111
55	5.23	730	.204	.202	856.6	2555.74	2641.23	0.00	-85.49	74616	.6187

TABLE 11-18.—NETWORK MODEL RESULTS—95-SEAT 1985 AUGMENTOR WING STOL—Continued

56	5.48	657	.181	.182	950.8	2298.00	2693.02	0.00	-395.02	74221	.6254
57	5.14	681	.199	.199	981.7	2383.97	2577.70	0.00	-193.73	74027	.6325
58	3.23	560	.238	.256	543.7	1960.59	1889.09	0.00	71.50	74099	.6383
59	5.27	779	.223	.221	933.9	2724.98	2683.74	0.00	41.24	74140	.6463
60	3.11	510	.236	.233	498.2	1784.99	1864.10	0.00	-79.11	74061	.6516
61	4.19	594	.193	.208	733.7	2077.29	2302.97	0.00	-225.68	73835	.6578
62	3.37	483	.221	.212	564.5	1691.59	1939.23	0.00	-247.65	73587	.6628
63	5.16	561	.167	.160	857.0	1963.16	2602.81	0.00	-639.65	72948	.6686
64	4.14	615	.198	.223	708.3	2151.41	2211.63	0.00	-60.22	72888	.6749
65	5.05	630	.174	.184	912.6	2205.54	2672.05	0.00	-466.51	72421	.6815
66	4.27	424	.150	.144	734.6	1483.91	2342.15	0.00	-858.23	71563	.6858
67	5.91	752	.182	.188	1026.0	2631.79	2927.77	0.00	-295.98	71267	.6936
68	6.54	800	.180	.183	1180.2	2800.03	3205.89	0.00	-405.86	70861	.7019
69	5.11	643	.172	.183	841.4	2249.70	2594.21	0.00	-344.51	70516	.7086
70	3.61	653	.270	.275	694.5	2285.24	2126.68	0.00	158.55	70675	.7153
71	4.16	549	.224	.193	754.6	1920.20	2353.12	0.00	-432.91	70242	.7210
72	3.79	483	.231	.195	699.3	1780.37	2129.32	0.00	-348.95	69893	.7260
73	5.88	724	.189	.173	958.0	2533.98	2967.72	0.00	-433.74	69459	.7335
74	2.59	594	.378	.313	523.9	2079.02	1916.90	0.00	162.12	69622	.7396

TABLE 11-18.—NETWORK MODEL RESULTS—95-SEAT 1985 AUGMENTOR WING STOL—*Concluded*

DAILY SUMMARY

Mean utilization, hours	4.66
Standard deviation of utilization, hours	0.907
Distance-weighted load factor	0.313
Nonweighted load factor	0.709
Total passengers carried	71 476
Total direct operating cost, dollars	181 051.78
Total indirect operating cost, dollars	57 288.06
Total revenue, dollars	250 673.35
Total profit, dollars	12 333.50
Mean passenger wait time, min	14.014
Total demand	96 640.0
Percent demand carried	73.96
Total revenue flights	2437
Total distance flown, miles	59 987.9
Total revenue passenger miles flown	1 734 688.9
Number ferry flights	51
Total distance ferried, miles	1600.8
Profit per passenger, dollars	0.173
Fleet size	74
Total gates required	54

TABLE 11-19.—NETWORK MODEL RESULTS—153-SEAT 1985 AUGMENTOR WING STOL

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	5.01	2508	.452	.468	861.3	8776.62	3264.20	0.00	5512.42	5512	.0259
2	5.93	1964	.323	.321	1061.0	6873.93	3658.94	0.00	3214.99	8727	.0463
3	5.62	2375	.380	.388	945.3	8310.79	3578.65	0.00	4732.14	13459	.0708
4	4.81	2121	.396	.408	815.6	7423.73	3181.26	0.00	4242.47	17702	.0928
5	5.45	2250	.356	.368	880.9	7874.70	3533.96	0.00	4340.73	22043	.1161
6	4.96	1655	.319	.309	840.2	5793.78	3249.57	0.00	2544.21	24587	.1332
7	5.49	1803	.292	.302	922.7	6309.84	3511.71	0.00	2798.13	27385	.1519
8	5.17	1319	.264	.261	976.9	4829.82	3241.91	0.00	1587.91	28973	.1655
9	3.92	1233	.306	.310	713.6	4315.46	2700.55	0.00	1614.92	30588	.1783
10	5.58	1705	.292	.293	986.9	5967.14	3505.04	0.00	2462.10	33050	.1959
11	4.99	1311	.275	.252	882.2	4671.21	3227.45	0.00	1443.76	34494	.2095
12	4.07	1104	.246	.249	683.3	3965.54	2933.21	0.00	1032.33	35526	.2209
13	4.77	1326	.259	.263	828.3	4675.01	3173.81	0.00	1501.20	37027	.2346
14	4.90	1459	.279	.272	852.3	5107.05	3257.90	0.00	1849.15	38876	.2497
15	4.44	1257	.237	.249	705.4	4398.89	3053.50	0.00	1345.40	40222	.2627
16	4.51	1559	.343	.319	761.2	5458.24	3041.01	0.00	2417.23	42639	.2789
17	5.03	1269	.264	.237	867.4	4460.30	3268.43	0.00	1191.87	43831	.2920
18	3.36	1129	.343	.335	619.8	4056.68	2430.46	0.00	1626.22	45457	.3037
19	3.48	725	.182	.190	578.8	2538.59	2555.76	0.00	-17.17	45440	.3112
20	3.11	874	.288	.260	560.0	3058.94	2440.21	0.00	618.74	46059	.3202
21	2.88	978	.310	.320	596.6	3424.40	2465.61	0.00	958.81	47018	.3303
22	4.59	1247	.224	.255	789.0	4363.18	3060.27	0.00	1302.91	48320	.3432
23	2.81	923	.265	.302	505.9	3230.83	2300.24	0.00	930.59	49251	.3528
24	3.71	848	.225	.222	664.0	2969.26	2614.85	0.00	354.41	49605	.3616
25	4.94	1132	.231	.218	864.8	3962.39	3215.35	0.00	747.04	50353	.3733
26	4.74	1076	.208	.213	817.2	3767.41	3131.12	0.00	636.29	50989	.3844
27	3.35	714	.199	.194	559.7	2499.09	2491.29	0.00	7.80	50997	.3918
28	3.02	755	.212	.235	588.5	2643.26	2460.03	0.00	183.22	51180	.3996
29	3.58	794	.190	.230	585.2	2780.68	2611.43	0.00	169.25	51349	.4079
30	4.69	1117	.217	.215	836.2	3909.19	3298.03	0.00	611.17	51960	.4194
31	3.87	809	.181	.139	703.1	2833.21	2898.20	0.00	-64.99	51895	.4278
32	6.07	1088	.174	.177	1082.0	3808.50	3724.75	0.00	83.75	51979	.4390
33	3.84	937	.232	.219	625.7	3279.10	2742.00	0.00	537.10	52516	.4487
34	4.50	942	.200	.187	796.0	3298.06	3218.90	0.00	79.15	52595	.4585
35	6.89	1221	.158	.153	1190.2	4273.42	4261.00	0.00	12.42	52608	.4711
36	4.35	773	.150	.163	761.0	2705.73	3040.86	0.00	-335.13	52273	.4791
37	3.90	764	.197	.192	739.7	2697.49	2769.20	0.00	-71.71	52201	.4870
38	4.50	911	.193	.196	791.7	3187.90	3062.14	0.00	125.77	52327	.4965
39	3.20	672	.201	.191	530.4	2352.76	2419.71	0.00	-66.95	52260	.5034
40	4.63	869	.180	.172	776.8	3040.15	3103.05	0.00	-62.90	52197	.5124
41	3.12	682	.187	.203	564.0	2387.05	2442.98	0.00	-55.92	52141	.5195
42	3.40	676	.189	.192	605.2	2365.97	2471.70	0.00	-105.73	52035	.5264
43	5.78	988	.167	.170	1060.7	3464.10	3556.24	0.00	-92.14	51943	.5367
44	5.41	945	.154	.154	866.6	3307.19	3524.06	0.00	-216.87	51726	.5465
45	5.16	954	.172	.178	948.6	3337.89	3376.01	0.00	-38.12	51688	.5563
46	6.45	986	.149	.147	1136.5	3452.63	3916.29	0.00	-463.66	51224	.5665
47	5.92	1021	.156	.159	994.8	3573.83	3766.76	0.00	-192.93	51031	.5771
48	5.96	1083	.146	.161	954.3	3788.91	3789.84	0.00	-.92	51030	.5883
49	6.31	1117	.158	.162	1058.7	3908.18	3913.57	0.00	-5.39	51025	.5998
50	3.94	735	.165	.178	723.3	2572.68	2809.75	0.00	-237.07	50788	.6075
51	5.23	846	.158	.158	940.6	2961.73	3319.21	0.00	-357.49	50431	.6162
52	5.05	849	.175	.159	875.1	2988.16	3273.77	0.00	-285.60	50145	.6250
53	5.06	746	.128	.128	794.1	2610.22	3371.24	0.00	-761.02	49384	.6327
54	4.00	627	.138	.141	656.2	2194.10	2814.39	0.00	-620.29	48764	.6392
55	3.23	669	.230	.208	699.7	2520.22	2588.41	0.00	-68.20	48695	.6461

TABLE 11-19.—NETWORK MODEL RESULTS—153-SEAT 1985 AUGMENTOR WING STOL—Continued

56	5.21	648	.119	.121	935.8	2258.80	3315.90	0.00	-1047.09	47648	.6528
57	3.96	746	.169	.168	676.0	2610.74	2879.33	0.00	-268.64	47380	.6606

TABLE 11-19.—NETWORK MODEL RESULTS—153-SEAT 1985 AUGMENTOR WING STOL—Concluded

DAILY SUMMARY

Mean utilization, hours	4.60
Standard deviation of utilization, hours	0.995
Distance-weighted load factor	0.227
Nonweighted load factor	0.227
Total passengers carried	63 836
Total direct operating cost, dollars	176 689.92
Total indirect operating cost, dollars	54 118.24
Total revenue, dollars	224 069.60
Total profit, dollars	-6738.56
Mean passenger wait time, min	14.411
Total demand	96 640.0
Percent demand carried	66.06
Total revenue flights	1835
Total distance flown, miles	45 636.0
Total revenue passenger miles flown	1 565 191.4
Number ferry flights	24
Total distance ferried, miles	601.1
Profit per passenger, dollars	-0.106
Fleet size	57
Total gates required	49

TABLE 11-20.—NETWORK MODEL RESULTS—50-SEAT 1985 HELICOPTER

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	9.57	2150	.662	.683	1202.9	7526.34	3211.37	0.00	4314.97	4315	.0186
2	9.24	2105	.675	.690	1255.5	7366.97	3123.32	0.00	4243.55	8559	.0367
3	9.07	2169	.680	.699	1182.0	7592.65	3116.58	0.00	4476.07	13035	.0555
4	9.42	2013	.691	.694	1347.9	7046.22	3119.48	0.00	3926.74	16961	.0729
5	8.74	1815	.645	.648	1213.4	6352.91	2963.16	0.00	3389.75	20351	.0885
6	8.72	2152	.766	.755	1193.9	7530.92	2972.57	0.00	4558.35	24909	.1071
7	7.97	1695	.637	.640	1052.1	5932.60	2760.48	0.00	3172.12	28082	.1218
8	7.78	1995	.705	.700	965.9	6983.21	2794.67	0.00	4188.54	32270	.1390
9	8.57	1713	.639	.647	1221.0	5997.17	2862.84	0.00	3134.32	35404	.1538
10	8.26	1616	.632	.622	1163.3	5656.85	2822.18	0.00	2834.67	38239	.1678
11	8.80	1703	.640	.655	1293.6	5959.00	2824.33	0.00	3134.67	41374	.1825
12	7.91	1563	.617	.625	1109.8	5469.80	2729.37	0.00	2740.43	43995	.1960
13	6.57	1219	.619	.610	945.9	4257.94	2346.62	0.00	1911.32	45906	.2065
14	8.40	1648	.672	.634	1195.7	5768.09	2847.60	0.00	2920.49	48826	.2207
15	7.61	1480	.625	.630	1085.1	5179.74	2634.54	0.00	2545.20	51371	.2335
16	7.32	1455	.670	.677	1080.9	5094.11	2528.76	0.00	2565.33	53937	.2461
17	7.10	1318	.649	.637	1041.8	4612.10	2472.64	0.00	2139.45	56076	.2574
18	4.77	953	.623	.635	672.8	3334.60	1878.33	0.00	1456.27	57532	.2657
19	7.91	1417	.628	.630	1139.7	4958.37	2664.91	0.00	2293.46	59826	.2779
20	6.07	1305	.640	.650	840.5	4566.03	2238.61	0.00	2327.42	62153	.2892
21	5.69	1113	.590	.601	780.7	3894.19	2140.84	0.00	1753.35	63906	.2988
22	5.66	1047	.615	.616	822.7	3654.43	2187.53	0.00	1466.90	65373	.3078
23	6.70	1408	.667	.697	961.1	4928.40	2384.00	0.00	2544.41	67918	.3200
24	4.68	741	.467	.494	650.6	2594.32	1860.92	0.00	733.40	68651	.3264
25	6.60	988	.517	.517	970.8	3457.94	2340.76	0.00	1117.18	69769	.3349
26	7.47	1288	.573	.572	1084.3	4507.35	2582.25	0.00	1925.08	71693	.3460
27	5.20	956	.539	.563	712.3	3747.40	2411.01	0.00	1336.40	73030	.3547
28	7.55	1186	.496	.595	1071.3	4150.97	2622.97	0.00	1528.00	74558	.3645
29	5.34	895	.509	.542	762.4	3132.21	2024.82	0.00	1107.39	75665	.3723
30	5.03	800	.502	.516	719.5	2799.71	1840.30	0.00	959.41	76625	.3792
31	5.27	855	.544	.535	760.6	2993.59	1997.96	0.00	995.63	77620	.3866
32	5.49	965	.530	.508	716.7	3378.45	2116.12	0.00	1262.33	78883	.3949
33	6.51	1086	.555	.557	948.4	3800.51	2323.29	0.00	1477.22	80360	.4043
34	5.89	915	.527	.538	878.7	3203.46	2141.38	0.00	1062.08	81422	.4122
35	5.79	913	.484	.494	805.6	3195.58	2160.28	0.00	1035.30	82457	.4201
36	4.93	868	.583	.599	726.5	3037.66	1894.91	0.00	1142.75	83600	.4276
37	5.34	677	.401	.398	745.1	2367.75	2036.66	0.00	331.09	83931	.4334
38	5.97	995	.508	.510	818.2	3483.26	2221.10	0.00	1262.16	85193	.4420
39	5.34	872	.518	.513	745.1	3052.74	2036.69	0.00	1016.05	86209	.4495
40	5.04	864	.601	.576	737.4	3023.95	1928.91	0.00	1095.04	87304	.4570
41	3.45	614	.567	.534	465.6	2149.93	1537.87	0.00	612.06	87916	.4623
42	4.88	779	.527	.519	597.8	2726.51	1897.89	0.00	828.64	88745	.4690
43	4.76	798	.562	.570	725.0	2794.41	1993.75	0.00	800.66	89545	.4759
44	5.61	845	.468	.497	818.3	3057.86	2144.90	0.00	912.96	90458	.4832
45	5.18	693	.471	.447	755.3	2427.14	1968.40	0.00	458.74	90917	.4892
46	5.93	839	.424	.441	848.3	2935.38	2244.70	0.00	690.68	91608	.4965
47	5.24	795	.511	.492	737.7	2781.14	2005.45	0.00	775.69	92384	.5033
48	5.33	678	.460	.452	807.5	2376.22	1983.48	0.00	392.74	92776	.5092
49	5.84	723	.415	.413	850.2	2531.04	2144.49	0.00	386.55	93163	.5154
50	5.49	806	.480	.489	798.2	2822.05	2052.91	0.00	769.15	93932	.5224
51	5.45	764	.455	.450	771.6	2675.06	2057.43	0.00	617.63	94549	.5290
52	6.45	868	.485	.492	983.2	3045.93	2274.18	0.00	771.75	95321	.5365
53	4.93	837	.420	.427	768.7	1966.10	1826.01	0.00	140.09	95461	.5411
54	6.45	837	.448	.429	959.2	2928.80	2356.31	0.00	572.49	96034	.5483
55	6.37	1372	.552	.523	881.8	3753.49	2321.79	0.00	1431.70	97465	.5576

TABLE 11-20.—NETWORK MODEL RESULTS—50-SEAT 1985 HELICOPTER—Continued

56	5.21	581	.372	.375	763.5	2032.27	1974.81	0.00	57.45	97523	.5626
57	5.25	692	.409	.432	756.2	2421.71	1994.55	0.00	427.15	97050	.5686
58	4.87	503	.364	.373	743.8	1761.43	1857.65	0.00	-96.17	97854	.5729
59	3.79	455	.386	.413	562.5	1591.38	1588.37	0.00	3.51	97857	.5768
60	6.15	610	.340	.349	924.5	2136.43	2202.74	0.00	-66.33	97791	.5821
61	3.77	488	.459	.465	566.0	1709.25	1565.68	0.00	143.57	97975	.5863
62	4.00	503	.411	.419	581.0	1760.29	1653.74	0.00	106.55	98041	.5907
63	5.67	736	.419	.433	874.9	2577.39	2189.29	0.00	388.10	98429	.5970
64	4.09	545	.380	.390	588.6	2009.16	1912.23	0.00	96.93	98525	.6017
65	3.87	557	.450	.446	607.1	1949.11	1775.91	0.00	173.20	98699	.6066
66	5.28	567	.390	.391	812.0	2004.07	1961.99	0.00	42.08	98741	.6115
67	3.78	554	.518	.503	511.9	1938.03	1599.55	0.00	338.48	99080	.6162
68	2.93	423	.445	.470	444.3	1480.52	1419.45	0.00	61.07	99141	.6199
69	5.65	656	.356	.375	877.9	2296.54	2242.47	0.00	54.06	99195	.6256
70	2.23	288	.451	.443	355.0	1008.12	1222.32	0.00	-214.19	99081	.6289
71	2.07	440	.467	.419	405.1	1539.79	1465.04	0.00	74.75	99066	.6318
72	3.72	447	.377	.344	530.1	1565.63	1715.59	0.00	-149.96	99006	.6357
73	6.41	713	.381	.375	941.0	2496.39	2291.93	0.00	204.46	99117	.6419
74	3.35	378	.441	.444	587.1	1421.44	1525.41	0.00	-103.97	99011	.6451
75	3.42	450	.470	.459	578.7	1574.19	1626.56	0.00	-52.37	98549	.6490
76	3.59	446	.438	.446	643.4	1559.33	1702.66	0.00	-143.33	98804	.6529
77	5.91	712	.414	.396	947.7	2492.27	2348.06	0.00	144.21	98949	.6590
78	5.10	643	.408	.443	917.7	2250.59	2017.28	0.00	233.31	99182	.6646
79	5.13	580	.406	.387	831.3	2030.52	2078.91	0.00	-48.39	99134	.6696
80	3.90	528	.408	.440	686.2	1849.05	1858.66	0.00	-9.61	99124	.6741
81	2.56	330	.431	.440	401.4	1155.77	1309.55	0.00	-153.78	99070	.6770
82	4.33	522	.399	.418	718.9	1828.66	1863.57	0.00	-34.90	99075	.6815
83	4.25	538	.381	.430	747.5	1831.39	1886.80	0.00	-55.41	99083	.6861
84	3.69	472	.421	.394	578.9	1653.24	1728.44	0.00	-75.20	99005	.6902
85	3.08	298	.284	.298	422.5	1042.81	1427.83	0.00	-385.01	98420	.6928
86	3.04	477	.532	.503	502.2	1670.82	1541.17	0.00	129.65	98549	.6969
87	5.36	642	.374	.367	757.6	2247.79	2097.36	0.00	150.43	98730	.7025
88	3.66	361	.394	.361	637.3	1343.71	1672.43	0.00	-328.72	98771	.7056
89	5.72	551	.292	.299	771.9	1928.96	2159.44	0.00	-230.48	98141	.7103
90	5.61	644	.344	.358	823.1	2255.06	2203.48	0.00	51.58	98102	.7159
91	3.94	400	.347	.364	625.0	1399.97	1662.84	0.00	-262.88	97929	.7194
92	4.82	463	.276	.272	618.1	1619.28	1937.11	0.00	-317.84	97612	.7234
93	5.42	582	.338	.353	903.1	2037.06	2262.27	0.00	-225.20	97386	.7284
94	5.28	582	.321	.324	771.1	2038.58	2184.19	0.00	-145.61	97241	.7334
95	4.51	458	.327	.339	705.8	1602.55	1878.74	0.00	-276.19	96065	.7374
96	3.65	.521	.473	.434	568.0	1824.42	1899.95	0.00	-75.52	95999	.7419
97	4.53	397	.277	.274	677.8	1389.11	1907.62	0.00	-518.51	96771	.7453
98	4.45	531	.340	.366	779.7	1856.77	2114.68	0.00	-257.91	95113	.7499
99	3.96	277	.211	.231	597.7	970.19	1692.29	0.00	-722.10	95391	.7523
100	4.77	369	.241	.246	671.8	1291.64	1877.50	0.00	-585.86	94895	.7555
101	4.01	242	.214	.211	648.7	847.87	1732.27	0.00	-884.40	93920	.7575
102	3.92	394	.283	.303	628.3	1378.76	1843.42	0.00	-464.65	93456	.7609
103	3.34	324	.311	.308	517.9	1132.71	1578.87	0.00	-446.15	93009	.7637
104	4.19	302	.271	.263	569.6	1089.48	1723.19	0.00	-633.71	92376	.7664
105	4.27	436	.262	.301	591.1	1526.74	1814.24	0.00	-287.50	92098	.7701
106	3.40	262	.211	.228	525.8	815.59	1561.15	0.00	-745.56	91743	.7724
107	2.99	248	.208	.226	393.6	868.35	1481.47	0.00	-613.12	90729	.7745
108	4.33	336	.261	.232	606.3	1176.59	1826.15	0.00	-649.56	90083	.7774
109	3.01	235	.268	.276	504.3	821.71	1466.53	0.00	-644.82	89435	.7795
110	3.25	290	.263	.290	537.3	1015.65	1594.06	0.00	-578.41	88957	.7820
111	3.18	225	.212	.237	487.3	748.77	1473.59	0.00	-599.81	88167	.7839
112	4.49	298	.207	.221	676.9	1043.76	1839.63	0.00	-795.87	87789	.7865

TABLE 11-20.—NETWORK MODEL RESULTS—50-SEAT 1985 HELICOPTER—Continued

113	3.31	216	.217	.228	520.1	757.44	1504.29	0.00	-746.85	86673	.7884
114	2.89	210	.214	.248	474.4	736.40	1443.03	0.00	-706.62	85927	.7902
115	1.40	213	.392	.426	250.7	745.00	1115.13	0.00	-370.13	83555	.7920
116	1.65	204	.429	.408	310.7	713.95	1162.19	0.00	-448.25	85108	.7938
117	1.94	228	.380	.414	341.0	797.14	1185.93	0.00	-388.79	84719	.7957
118	3.12	211	.262	.222	522.3	745.05	1556.88	0.00	-811.83	83908	.7976
119	2.02	206	.392	.308	377.3	701.23	1316.06	0.00	-614.83	83293	.7993

TABLE 11-20.—NETWORK MODEL RESULTS—50-SEAT 1985 HELICOPTER—Concluded

DAILY SUMMARY

Mean utilization, hours	5.15
Standard deviation of utilization, hours	1.793
Distance-weighted load factor	0.482
Nonweighted load factor	0.487
Total passengers carried	92 550
Total direct operating cost, dollars	240 983.40
Total indirect operating cost, dollars	67 436.45
Total revenue, dollars	324 276.10
Total profit, dollars	15 856.24
Mean passenger wait time, min	14.098
Total demand	115 792.0
Percent demand carried	79.93
Total revenue flights	3801
Total distance flown, miles	90 538.2
Total revenue passenger miles flown	2 107 151.4
Number ferry flights	133
Total distance ferried, miles	3081.2
Profit per passenger, dollars	0.171
Fleet size	119
Total gates required	67

TABLE 11-21.—NETWORK MODEL RESULTS—98-SEAT 1985 HELICOPTER

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	5.72	2201	.548	.561	751.6	7791.95	3099.96	0.00	4691.99	4692	.0190
2	6.49	2347	.551	.544	875.9	8214.95	3280.08	0.00	4934.87	9627	.0393
3	6.29	2357	.587	.601	892.6	8249.41	3251.29	0.00	4998.12	14625	.0596
4	5.86	2023	.572	.543	818.1	7079.66	3088.01	0.00	3991.65	18617	.0771
5	5.04	1525	.503	.502	731.3	5338.13	2748.12	0.00	2590.01	21207	.0903
6	5.89	1782	.489	.491	842.5	6235.59	3087.55	0.00	3148.04	24355	.1057
7	5.73	1898	.513	.510	786.1	6642.18	3063.64	0.00	3578.54	27933	.1220
8	5.91	1919	.533	.529	848.7	6715.34	3094.12	0.00	3621.22	31554	.1386
9	4.83	1476	.469	.496	673.4	5165.14	2692.33	0.00	2472.81	34027	.1514
10	6.07	1875	.454	.467	820.6	6560.84	3210.67	0.00	3350.17	37377	.1675
11	6.14	1802	.415	.429	806.6	6335.48	3198.92	0.00	3136.56	40514	.1831
12	6.02	1645	.448	.454	874.2	5758.60	3121.58	0.00	2637.02	43151	.1973
13	4.37	1285	.469	.452	600.2	4496.52	2533.97	0.00	1962.55	45114	.2084
14	5.78	1676	.456	.450	798.0	5964.72	3076.34	0.00	2888.38	48002	.2229
15	6.25	1451	.416	.393	916.0	5078.83	3203.15	0.00	1875.68	49878	.2354
16	6.60	1547	.404	.405	985.6	5414.37	3314.55	0.00	2099.82	51977	.2488
17	6.87	1446	.343	.328	952.8	5062.17	3499.22	0.00	1562.95	53540	.2613
18	5.62	1334	.377	.389	609.5	4667.29	3077.66	0.00	1589.63	55130	.2728
19	6.04	1322	.333	.337	829.7	4625.67	3183.70	0.00	1441.97	56572	.2842
20	4.99	1142	.398	.376	720.2	3995.34	2736.17	0.00	1259.17	57831	.2941
21	4.84	1002	.335	.330	683.5	3597.93	2686.86	0.00	911.07	58742	.3027
22	5.61	1000	.313	.309	840.7	3500.15	2938.90	0.00	561.25	59303	.3113
23	6.72	1289	.342	.337	1013.6	4510.73	3344.57	0.00	1166.16	60470	.3225
24	4.46	850	.287	.280	589.9	2974.22	2596.21	0.00	378.01	60848	.3298
25	6.55	1242	.287	.295	906.3	4746.40	3775.97	0.00	970.43	61818	.3405
26	5.51	1025	.299	.317	815.0	3587.63	2911.28	0.00	676.35	62494	.3494
27	3.62	564	.261	.274	570.2	1972.43	2245.17	0.00	-272.74	62221	.3543
28	4.57	886	.341	.335	682.5	3100.27	2549.08	0.00	551.19	62773	.3619
29	4.43	746	.276	.282	645.5	2611.30	2510.35	0.00	100.95	62874	.3684
30	4.91	910	.290	.319	716.7	3185.92	2695.80	0.00	490.12	63364	.3762
31	6.51	1167	.302	.305	987.0	4084.86	3352.73	0.00	732.13	64096	.3863
32	6.89	1226	.284	.291	1016.1	4291.19	3530.55	0.00	760.64	64857	.3969
33	3.38	587	.288	.299	504.6	2053.18	2101.35	0.00	-48.17	64809	.4019
34	3.92	568	.259	.276	668.9	2041.20	2387.82	0.00	-346.62	64462	.4069
35	4.02	702	.268	.275	564.1	2455.54	2385.17	0.00	70.37	64533	.4129
36	3.51	648	.296	.310	503.4	2266.36	2173.39	0.00	92.97	64626	.4185
37	5.91	1047	.287	.299	846.7	3573.91	3001.98	0.00	571.93	65198	.4275
38	4.50	715	.284	.280	680.2	2590.97	2599.92	0.00	-8.95	65189	.4337
39	4.12	664	.281	.260	611.2	2322.34	2472.51	0.00	-150.17	65038	.4394
40	4.07	635	.263	.259	592.6	2223.96	2379.22	0.00	-155.26	64883	.4449
41	3.21	641	.317	.327	486.2	2243.38	2118.20	0.00	125.18	65008	.4505
42	4.26	891	.366	.350	647.1	3119.01	2510.99	0.00	608.01	65616	.4582
43	5.15	704	.265	.256	837.5	2571.60	2719.95	0.00	-148.35	65468	.4642
44	4.95	719	.228	.229	692.6	2516.00	2743.13	0.00	-227.13	65241	.4705
45	2.96	562	.311	.319	434.5	1967.71	1952.70	0.00	15.01	65256	.4753
46	4.95	822	.278	.279	725.6	2875.55	2705.31	0.00	170.24	65426	.4824
47	4.69	826	.304	.291	704.2	2892.60	2682.34	0.00	210.25	65636	.4905
48	3.74	597	.269	.277	584.1	2090.93	2296.75	0.00	-205.82	65430	.4947
49	3.94	713	.341	.303	576.0	2494.61	2324.70	0.00	169.91	65600	.5009
50	5.71	850	.252	.248	873.0	2973.71	3002.91	0.00	-29.19	65571	.5082
51	4.07	673	.264	.264	565.2	2354.75	2386.43	0.00	-31.68	65539	.5140
52	3.53	505	.262	.245	525.5	1768.22	2160.51	0.00	-392.29	65147	.5184
53	4.07	723	.275	.295	592.6	2531.31	2378.63	0.00	152.68	65300	.5246
54	4.47	949	.368	.334	672.9	3320.58	2685.28	0.00	635.30	65935	.5328
55	5.48	767	.234	.237	808.6	2683.37	2904.41	0.00	-221.04	65714	.5404

TABLE 11-21.—NETWORK MODEL RESULTS—98-SEAT 1985 HELICOPTER—Continued

56	5.74	868	.242	.246	879.9	3039.06	3154.72	0.00	-115.65	65199	.5469
57	3.75	556	.231	.237	528.1	1947.53	2273.20	0.00	-325.67	64873	.5517
58	6.13	902	.236	.230	852.3	3155.82	3207.01	0.00	-51.19	64822	.5595
59	4.12	563	.255	.250	636.3	2302.20	2652.84	0.00	-350.64	64471	.5644
60	3.34	576	.279	.294	517.6	2016.43	2151.95	0.00	-135.52	64336	.5694
61	5.38	713	.210	.220	807.8	2494.69	2940.20	0.00	-445.52	63890	.5755
62	7.39	987	.211	.219	1177.0	3455.15	3843.74	0.00	-388.59	63502	.5840
63	6.11	685	.188	.194	914.0	2396.84	3127.67	0.00	-730.84	62771	.5900
64	4.58	774	.238	.253	636.3	2707.63	2609.42	0.00	98.21	62869	.5966
65	7.13	895	.196	.209	1031.9	3133.75	3547.53	0.00	-413.79	62455	.6044
66	6.91	1045	.243	.257	1069.0	3658.34	3477.43	0.00	180.91	62635	.6134
67	4.91	711	.199	.227	684.6	2488.00	2734.66	0.00	-246.66	62390	.6195
68	2.51	471	.249	.257	346.6	1647.03	1894.99	0.00	-247.96	62142	.6236
69	4.26	727	.237	.265	590.3	2544.63	2486.69	0.00	57.96	62200	.6299
70	4.55	693	.270	.236	626.6	2426.93	2598.96	0.00	-172.03	62027	.6359
71	4.15	488	.212	.199	614.9	1707.89	2303.13	0.00	-595.24	61432	.6401
72	6.20	759	.200	.204	927.3	2656.69	3351.95	0.00	-695.27	60737	.6466
73	6.13	674	.188	.176	941.9	2357.55	3377.55	0.00	-1020.00	59717	.6525
74	5.26	571	.166	.171	736.4	1997.75	2863.57	0.00	-865.82	58851	.6574
75	4.66	604	.209	.213	670.6	2115.05	2609.56	0.00	-494.52	58357	.6626
76	3.93	422	.182	.179	574.4	1475.99	2322.95	0.00	-846.96	57510	.6662
77	3.73	484	.251	.247	590.5	1776.95	2193.64	0.00	-416.79	57093	.6704
78	6.10	671	.172	.171	844.2	2359.12	3208.28	0.00	-849.16	56244	.6762
79	5.02	550	.194	.187	765.9	1925.14	2886.31	0.00	-961.17	55283	.6810
80	6.33	682	.172	.166	868.7	2397.26	3208.99	0.00	-811.72	54471	.6869
81	3.70	439	.216	.204	550.4	1536.27	2233.83	0.00	-697.56	53773	.6907
82	5.43	627	.190	.183	761.8	2193.31	2927.51	0.00	-734.20	53049	.6961
83	4.55	549	.170	.175	595.3	1920.71	2639.72	0.00	-719.02	52331	.7019
84	5.02	605	.213	.213	809.4	2115.87	2831.95	0.00	-716.09	51615	.7060
85	5.92	613	.190	.194	924.2	2144.51	3101.90	0.00	-957.39	50658	.7113
86	4.38	524	.206	.191	692.0	1932.65	2805.90	0.00	-873.25	49784	.7158
87	4.45	393	.140	.143	659.7	1375.21	2597.93	0.00	-1222.72	48562	.7192
88	5.73	671	.228	.201	876.5	2391.68	3050.72	0.00	-659.04	47903	.7250
89	4.64	410	.138	.144	666.4	1433.94	2605.07	0.00	-1171.13	46731	.7296
90	5.76	556	.167	.162	794.8	1947.55	3146.32	0.00	-1198.77	45543	.7334
91	4.50	510	.212	.193	714.5	1783.74	2556.71	0.00	-772.98	44770	.7378
92	3.48	435	.221	.211	560.7	1521.29	2271.57	0.00	-750.28	44019	.7415
93	3.08	394	.243	.223	511.7	1393.16	2109.01	0.00	-715.85	43304	.7449
94	3.10	394	.183	.201	508.7	1377.47	2215.76	0.00	-839.29	42465	.7493

TABLE 11-21.—NETWORK MODEL RESULTS—98-SEAT 1985 HELICOPTER—Concluded

DAILY SUMMARY

Mean utilization, hours	5.01
Standard deviation of utilization, hours	1.106
Distance-weighted load factor	0.297
Nonweighted load factor	0.300
Total passengers carried	86 651
Total direct operating cost, dollars	261 144.36
Total indirect operating cost, dollars	62 050.53
Total revenue, dollars	303 609.62
Total profit, dollars	-19 585.27
Mean passenger wait time, min	14.336
Total demand	115 792.0
Percent demand carried	74.83
Total revenue flights	2943
Total distance flown, miles	68 843.9
Total revenue passenger miles flown	1 975 018.4
Number ferry flights	45
Total distance ferried, miles	985.5
Profit per passenger, dollars	-0.226
Fleet size	94
Total gates required	55

TABLE 11-22.—NETWORK MODEL RESULTS—150-SEAT 1985 HELICOPTER

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	4.71	2158	.448	.436	622.1	7552.27	3437.28	0.00	4114.99	4115	.0186
2	5.94	2338	.396	.400	804.1	8181.58	3969.57	0.00	4212.01	8327	.0388
3	6.31	2222	.347	.361	988.8	7777.33	4179.71	0.00	3598.23	11925	.0580
4	6.02	2344	.369	.363	782.8	8204.16	4129.84	0.00	4074.32	16000	.0793
5	6.16	2096	.350	.349	866.4	7334.84	4101.83	0.00	3233.00	19233	.0964
6	5.49	1911	.357	.386	817.5	6687.29	3703.78	0.00	2983.51	22216	.1129
7	4.78	1390	.346	.331	724.1	4865.87	3339.84	0.00	1526.03	23742	.1249
8	5.38	1563	.344	.336	747.5	5470.92	3513.74	0.00	1957.18	25699	.1384
9	4.22	1208	.306	.298	603.2	4229.12	3123.49	0.00	1105.63	26805	.1488
10	4.84	1521	.332	.327	689.3	5324.37	3934.28	0.00	1390.09	28195	.1519
11	5.37	1882	.309	.299	850.4	6586.15	4174.68	0.00	2411.47	30606	.1782
12	5.88	1960	.312	.333	814.9	6225.03	3884.21	0.00	2340.82	32947	.1950
13	6.25	1767	.317	.318	979.9	6134.67	4010.12	0.00	2124.55	35072	.2103
14	6.37	1675	.258	.272	897.6	5763.33	4186.28	0.00	1577.05	36649	.2248
15	5.52	1474	.344	.327	874.5	5455.29	3529.56	0.00	1925.73	38575	.2375
16	4.98	1284	.276	.259	690.1	4493.04	3530.06	0.00	962.97	39537	.2486
17	5.28	1138	.275	.245	708.4	3981.55	3582.08	0.00	399.47	39936	.2584
18	5.54	1307	.292	.281	962.5	4623.58	3670.47	0.00	953.11	40889	.2697
19	5.70	1302	.245	.241	819.0	4557.02	3847.91	0.00	709.11	41598	.2803
20	3.57	826	.241	.250	522.6	2901.37	2791.06	0.00	110.31	41708	.2881
21	4.07	906	.276	.272	590.1	3169.77	3047.79	0.00	121.98	41830	.2959
22	5.12	1083	.244	.241	774.4	3791.50	3503.06	0.00	288.44	42118	.3052
23	4.23	1143	.262	.282	602.8	3099.42	3127.05	0.00	-27.63	42091	.3151
24	5.32	1213	.243	.238	759.2	4246.83	3670.28	0.00	576.55	42668	.3256
25	4.77	1118	.220	.240	670.4	3911.56	3408.54	0.00	503.01	43171	.3352
26	4.24	976	.237	.223	588.8	3276.43	3155.27	0.00	121.16	43292	.3473
27	3.74	817	.233	.249	563.4	2859.53	2837.55	0.00	21.98	43314	.3604
28	5.22	1004	.190	.197	737.7	3512.44	3636.84	0.00	-124.40	43190	.3690
29	3.81	910	.255	.264	566.5	3193.74	2898.15	0.00	295.59	43485	.3769
30	5.36	1203	.247	.251	800.9	4210.35	3633.86	0.00	576.49	44061	.3873
31	4.81	966	.234	.222	714.3	3381.38	3373.75	0.00	7.63	44069	.3956
32	3.64	956	.225	.245	473.7	3345.50	2903.65	0.00	441.85	44511	.3979
33	2.70	644	.219	.215	339.2	2253.73	2434.88	0.00	-181.15	44330	.4004
34	4.28	811	.176	.200	616.6	2838.03	3145.82	0.00	-307.79	44022	.4064
35	4.58	844	.189	.194	657.9	2965.57	3306.77	0.00	-341.20	43681	.4137
36	3.51	646	.182	.187	491.9	2260.21	2786.51	0.00	-526.29	43154	.4193
37	5.01	917	.209	.211	764.5	3209.88	3442.15	0.00	-232.27	42922	.4272
38	3.75	773	.209	.215	608.5	2704.66	3134.83	0.00	-430.17	42492	.4339
39	4.23	996	.227	.246	651.9	3437.22	3238.64	0.00	198.58	42691	.4425
40	5.47	1018	.237	.200	785.0	3563.16	3706.83	0.00	-143.67	42547	.4513
41	5.35	1014	.179	.193	750.0	3548.94	3706.39	0.00	-157.45	42389	.4601
42	5.05	873	.186	.182	727.0	3054.02	3527.64	0.00	-473.63	41916	.4676
43	4.62	780	.178	.173	640.7	2730.51	3332.93	0.00	-602.42	41313	.4743
44	8.09	1217	.153	.166	1247.2	4260.11	5141.79	0.00	-881.68	40432	.4849
45	3.91	803	.220	.206	540.7	2811.63	2994.96	0.00	-183.33	40248	.4918
46	5.03	982	.185	.197	670.7	3437.83	3597.74	0.00	-159.91	40088	.5003
47	5.54	958	.183	.177	780.8	3352.02	3795.02	0.00	-442.99	39645	.5085
48	5.23	856	.189	.184	810.1	2996.53	3646.37	0.00	-649.85	38996	.5159
49	4.17	713	.179	.176	589.5	2497.23	3108.91	0.00	-611.69	38384	.5221
50	6.65	912	.145	.148	972.3	3113.51	4303.58	0.00	-1190.06	37194	.5300
51	3.22	655	.205	.218	494.5	2291.74	2695.33	0.00	-403.59	36790	.5356
52	6.87	968	.169	.157	1027.5	3383.75	4362.84	0.00	-979.09	35811	.5440
53	6.62	1073	.157	.172	981.8	3614.14	4258.13	0.00	-643.99	35167	.5529
54	6.68	953	.158	.159	896.8	3935.14	4279.62	0.00	-344.48	34822	.5611
55	4.06	606	.174	.155	578.7	2120.76	3046.78	0.00	-926.02	33896	.5664

TABLE 11-22.–NETWORK MODEL RESULTS–150-SEAT 1985 HELICOPTER–Continued

56	6.19	821	.146	.144	908.1	2873.66	4064.05	0.00	-1190.39	34095	.5735
57	6.65	862	.147	.144	390.1	3017.68	4270.52	0.00	-1252.84	33843	.5809
58	4.96	851	.168	.177	701.5	2979.38	3498.35	0.00	-518.97	32324	.5883
59	6.56	761	.128	.130	982.3	2663.47	4212.57	0.00	-1549.10	31774	.5948
60	5.84	939	.155	.174	853.5	3285.39	3894.88	0.00	-609.49	30165	.6029
61	5.69	686	.140	.135	851.3	2401.42	3797.20	0.00	-1395.79	28769	.6089
62	6.28	921	.161	.166	947.1	3223.32	4069.94	0.00	-846.63	27923	.6168
63	5.35	665	.128	.127	748.6	2326.67	3704.47	0.00	-1377.80	26545	.6226
64	5.86	779	.141	.137	927.0	2725.79	3953.44	0.00	-1227.65	25717	.6293
65	4.97	748	.157	.147	697.1	2618.56	3634.33	0.00	-1015.77	24701	.6358
66	5.26	600	.128	.125	775.3	2100.35	3600.27	0.00	-1499.92	22801	.6459

TABLE 11-22.—NETWORK MODEL RESULTS—150-SEAT 1985 HELICOPTER—Concluded

DAILY SUMMARY

Mean utilization, hours	5.17
Standard deviation of utilization, hours	1.027
Distance-weighted load factor	0.227
Nonweighted load factor	0.230
Total passengers carried	74 215
Total direct operating cost, dollars	237 308.88
Total indirect operating cost, dollars	56 971.93
Total revenue, dollars	260 110.31
Total profit, dollars	-34 170.50
Mean passenger wait time, min	14.378
Total demand	115 792.0
Percent demand carried	64.09
Total revenue flights	2147
Total distance flown, miles	49 446.2
Total revenue passenger miles flown	1 680 999.1
Number ferry flights	10
Total distance ferried, miles	174.3
Profit per passenger, dollars	-0.460
Fleet size	66
Total gates required	49

TABLE 11-23.—NETWORK MODEL RESULTS—50-SEAT TILT ROTOR

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	8.73	2450	.649	.671	1341.2	8573.96	2973.74	0.00	5600.22	5600	.0187
2	9.34	2288	.684	.693	1368.2	8099.93	2913.71	0.00	5195.21	10795	.0361
3	8.39	2258	.716	.705	1432.7	7901.58	2704.29	0.00	5107.31	15903	.0533
4	8.79	2407	.701	.718	1501.1	8423.93	2899.01	0.00	5524.33	21427	.0716
5	7.97	2175	.696	.691	1309.6	7613.19	2712.17	0.00	4901.02	26329	.0882
6	7.18	1951	.707	.723	1243.7	6829.94	2460.24	0.00	4369.63	30697	.1030
7	8.43	2105	.650	.658	1445.8	7767.57	2800.35	0.00	4567.31	35265	.1191
8	7.95	2209	.713	.701	1702.8	7731.37	2709.49	0.00	5021.99	40287	.1359
9	7.02	1819	.645	.649	1141.6	6354.93	2462.27	0.00	3902.65	44189	.1497
10	7.17	1784	.611	.615	1148.4	6244.47	2514.71	0.00	3729.75	47919	.1633
11	7.52	2050	.731	.745	1337.8	7174.68	2529.48	0.00	4646.20	52565	.1789
12	7.52	1826	.674	.630	1269.5	6390.13	2570.80	0.00	3819.33	56385	.1928
13	7.51	1965	.692	.678	1263.6	6878.31	2569.09	0.00	4310.22	60695	.2078
14	6.72	1875	.646	.658	1013.1	6562.95	2427.40	0.00	4135.55	64830	.2221
15	6.93	1648	.649	.659	1248.1	5765.76	2363.69	0.00	3403.07	68233	.2346
16	7.10	1747	.682	.672	1262.5	6114.55	2419.69	0.00	3694.87	71928	.2479
17	5.11	1112	.583	.618	942.5	3891.71	1477.06	0.00	2014.65	73943	.2564
18	6.51	1554	.622	.634	1126.5	5433.52	2282.71	0.00	3155.80	77099	.2682
19	6.72	1544	.669	.671	1129.9	5403.29	2210.36	0.00	3192.92	80292	.2800
20	4.99	1287	.697	.696	876.2	4506.04	1971.03	0.00	2535.01	82827	.2898
21	6.07	1490	.667	.662	1064.4	5215.29	2155.37	0.00	3059.92	85887	.3011
22	5.71	1274	.597	.579	963.5	4458.98	2083.99	0.00	2374.99	88262	.3108
23	5.04	1185	.623	.608	847.4	4146.86	1906.99	0.00	2239.88	90501	.3198
24	5.91	1412	.596	.588	934.5	4941.42	2155.29	0.00	2786.13	93287	.3306
25	5.65	1225	.603	.597	1012.8	4285.90	2032.83	0.00	2252.91	95540	.3399
26	4.02	808	.475	.489	632.1	2826.54	1659.39	0.00	1167.15	96707	.3461
27	4.82	1161	.555	.590	747.3	4062.32	1885.29	0.00	2177.03	98885	.3549
28	6.13	1332	.588	.579	1062.2	4663.47	2179.01	0.00	2484.45	101369	.3651
29	4.91	1045	.587	.580	970.3	3656.76	1843.66	0.00	1913.11	103282	.3730
30	4.97	1018	.545	.550	869.5	3562.23	1967.91	0.00	1594.32	104976	.3808
31	5.84	1314	.606	.537	1010.7	4598.18	2165.87	0.00	2432.31	107469	.3908
32	4.67	1006	.582	.559	787.3	3522.65	1805.22	0.00	1717.43	109186	.3984
33	4.60	1025	.531	.570	764.2	3588.59	1794.51	0.00	1794.09	110980	.4062
34	4.28	954	.568	.578	721.7	3340.40	1700.89	0.00	1639.51	112620	.4135
35	4.45	944	.563	.555	758.1	3302.41	1742.38	0.00	1560.03	114180	.4207
36	5.37	983	.481	.504	858.0	3441.43	1911.87	0.00	1529.56	115709	.4282
37	5.71	1206	.542	.548	964.5	4219.93	2084.44	0.00	2135.49	117845	.4374
38	5.14	1027	.565	.541	904.8	3594.45	1909.92	0.00	1685.53	119530	.4452
39	4.48	958	.643	.638	860.1	3446.17	1691.02	0.00	1755.16	121286	.4525
40	4.40	996	.632	.622	787.4	3494.59	1716.67	0.00	1777.92	123064	.4601
41	5.99	1130	.554	.526	1083.4	3955.72	2114.89	0.00	1840.84	124905	.4687
42	5.20	1110	.588	.600	948.3	3283.47	1904.40	0.00	1379.07	126284	.4771
43	4.90	930	.508	.517	862.6	3256.11	1843.39	0.00	1412.72	127696	.4842
44	4.98	867	.436	.456	849.5	3033.37	1883.23	0.00	1150.14	128846	.4908
45	3.82	838	.536	.541	607.7	2933.26	1598.77	0.00	1334.49	130181	.4972
46	4.41	805	.480	.488	767.1	2918.96	1721.01	0.00	1197.96	131378	.5033
47	5.06	810	.430	.438	900.4	2834.61	1882.24	0.00	952.37	132330	.5095
48	5.07	1070	.543	.578	904.3	3744.59	1884.05	0.00	1860.55	134191	.5176
49	4.40	705	.491	.497	796.6	2783.21	1706.28	0.00	1076.93	135268	.5237
50	5.12	865	.444	.455	800.3	3026.10	1906.35	0.00	1119.75	136387	.5303
51	3.70	584	.411	.417	636.5	2045.45	1538.17	0.00	507.28	136895	.5347
52	4.09	693	.433	.452	726.5	2426.35	1629.15	0.00	797.19	137692	.5400
53	4.10	761	.493	.431	705.9	2963.59	1644.23	0.00	1319.46	139012	.5458
54	3.99	715	.492	.493	782.9	2503.59	1679.91	0.00	823.67	139835	.5512
55	5.28	865	.432	.455	989.0	3028.53	1872.54	0.00	1155.96	140991	.5578

TABLE 11-23.—NETWORK MODEL RESULTS—50-SEAT TILT ROTOR—Continued

56	3.80	545	.412	.403	692.8	1995.79	1539.60	0.00	366.20	141457	.5620
57	4.60	761	.467	.476	926.7	2663.72	1920.44	0.00	943.29	142399	.5678
58	5.01	924	.519	.513	941.8	3234.18	1901.40	0.00	1332.78	143633	.5748
59	4.03	600	.424	.414	729.1	2098.88	1605.68	0.00	493.20	144126	.5794
60	3.28	553	.442	.442	593.9	1934.22	1469.15	0.00	465.07	144591	.5836
61	3.38	524	.432	.436	721.3	1832.85	1552.80	0.00	280.05	144872	.5876
62	2.70	565	.609	.565	613.9	1976.74	1429.07	0.00	547.67	145419	.5919
63	3.61	479	.360	.393	779.7	1677.21	1604.47	0.00	72.75	145492	.5955
64	2.76	511	.561	.569	611.9	1868.17	1329.59	0.00	538.58	146031	.5994
65	2.92	517	.482	.492	509.4	1809.15	1397.26	0.00	411.89	146442	.6033
66	5.94	828	.383	.368	1126.5	2899.09	2258.09	0.00	641.00	147083	.6097
67	4.04	603	.403	.377	663.3	2109.31	1649.16	0.00	460.15	147544	.6142
68	4.03	594	.411	.424	857.8	2078.52	1712.73	0.00	365.79	147909	.6188
69	5.12	665	.408	.331	1024.0	2455.57	1890.19	0.00	565.38	148475	.6238
70	3.52	633	.511	.506	816.3	2214.87	1670.72	0.10	544.15	149019	.6286
71	4.92	779	.445	.421	920.9	2729.21	1941.01	0.00	787.20	149806	.6346
72	4.04	576	.373	.397	836.0	2015.49	1729.16	0.00	286.32	150092	.6390
73	3.07	635	.537	.552	672.9	2222.18	1530.77	0.00	691.81	150784	.6438
74	6.47	984	.415	.410	1273.9	3444.01	2424.95	0.00	1019.06	151803	.6513
75	5.19	709	.359	.383	1085.0	2481.13	2066.29	0.00	414.84	152219	.6567
76	4.07	660	.434	.440	789.8	2309.50	1707.79	0.00	602.12	152820	.6617
77	4.83	721	.368	.400	682.0	2521.92	1993.95	0.00	527.97	153348	.6672
78	5.39	710	.355	.364	1072.9	2484.94	2085.36	0.00	399.58	153748	.6726
79	4.68	642	.374	.401	989.1	2245.82	1874.00	0.00	371.82	154120	.6775
80	3.96	616	.385	.395	739.9	2156.22	1758.62	0.00	397.61	154517	.6822
81	5.93	723	.313	.321	1017.9	2530.88	2133.85	0.00	397.02	154914	.6877
82	2.45	410	.424	.456	607.9	1435.33	1401.65	0.00	33.68	154948	.6908
83	6.28	849	.369	.377	1242.1	2969.78	2311.63	0.00	658.15	155606	.6973
84	3.71	547	.375	.390	745.9	1913.16	1662.78	0.00	250.38	155956	.7014
85	5.10	683	.353	.350	868.1	2389.93	1916.58	0.00	473.35	156330	.7066
86	2.97	444	.432	.386	637.3	1552.58	1513.87	0.00	38.71	156369	.7100
87	2.82	310	.290	.296	493.9	1086.48	1299.57	0.00	-213.10	156155	.7124
88	5.79	736	.303	.377	1715.6	2680.67	2271.71	0.00	408.96	156564	.7180
89	4.03	567	.384	.366	854.8	1985.24	1836.46	0.00	148.78	156713	.7223
90	3.93	571	.368	.357	693.3	1999.37	1712.36	0.00	287.01	157000	.7267
91	3.43	402	.328	.322	752.8	1408.11	1616.67	0.00	-208.56	156792	.7297
92	5.05	540	.263	.284	909.7	1891.36	1935.82	0.00	-44.46	156747	.7338
93	3.37	547	.420	.421	776.1	1914.27	1701.41	0.00	212.86	156960	.7380
94	3.45	389	.307	.311	689.9	1360.31	1538.24	0.00	-177.93	156782	.7410
95	3.96	654	.406	.422	864.7	2287.58	1865.68	0.00	421.91	157204	.7459
96	4.14	362	.240	.259	827.5	1267.32	1649.42	0.00	-382.10	156822	.7487
97	4.17	533	.322	.323	823.3	1864.51	1846.51	0.00	17.99	156840	.7528
98	3.77	410	.245	.274	513.8	1436.60	1576.97	0.00	-140.37	156699	.7559
99	2.13	250	.202	.346	461.5	907.44	1185.98	0.00	-278.54	156421	.7579
100	3.16	300	.226	.250	541.9	1049.52	1395.74	0.00	-346.22	156075	.7601
101	3.87	411	.245	.265	659.4	1437.49	1647.36	0.00	-209.87	155865	.7633
102	3.93	372	.221	.232	601.7	1301.54	1711.61	0.00	-410.07	155455	.7661
103	3.42	289	.185	.214	561.5	1011.85	1478.80	0.00	-466.95	154989	.7683
104	3.04	317	.235	.276	558.0	1110.17	1403.22	0.00	-293.05	154695	.7707
105	3.89	431	.264	.278	702.0	1508.66	1691.76	0.00	-183.10	154512	.7740
106	4.76	335	.204	.203	924.0	1187.84	1819.21	0.00	-631.37	153880	.7765
107	4.93	463	.222	.250	889.9	1620.15	1902.02	0.00	-281.87	153598	.7801
108	3.61	329	.269	.253	651.6	1149.94	1495.86	0.00	-345.92	153253	.7826
109	3.61	386	.287	.297	687.1	1350.34	1536.03	0.00	-186.09	153066	.7855
110	2.14	255	.297	.319	407.9	893.65	1161.15	0.00	-267.51	152799	.7875
111	3.28	238	.203	.190	561.4	833.17	1429.45	0.00	-596.28	152203	.7893
112	2.65	223	.270	.248	572.3	825.93	1311.22	0.00	-485.29	151717	.7910

TABLE 11-23.—NETWORK MODEL RESULTS—50-SEAT TILT ROTOR—Continued

113	2.34	244	.246	.271	429.8	854.35	1220.69	0.00	-366.25	151351	.7928
114	2.55	218	.158	.207	435.1	751.96	1296.39	0.00	-535.93	150916	.7945
115	2.85	221	.209	.211	537.8	774.42	1344.53	0.00	-570.12	150246	.7962
116	2.30	221	.221	.250	508.4	773.02	1281.65	0.00	-508.63	149737	.7979
117	3.23	256	.175	.205	544.4	897.64	1421.58	0.00	-523.94	149213	.7998
118	2.70	261	.245	.261	544.2	912.13	1347.52	0.00	-435.39	148778	.8018
119	3.22	234	.190	.195	597.0	810.79	1445.94	0.00	-626.16	148152	.8036
120	2.84	275	.217	.262	607.1	963.29	1424.09	0.00	-460.80	147601	.8057
121	2.85	273	.237	.260	640.8	954.91	1466.22	0.00	-511.31	147180	.8077
122	1.92	215	.291	.307	412.7	753.12	1138.70	0.00	-385.59	146794	.8094
123	1.57	209	.297	.348	407.4	731.78	1111.69	0.00	-379.91	146414	.8110
124	2.26	268	.250	.297	505.7	936.90	1329.69	0.00	-392.79	145921	.8130
125	1.75	220	.381	.367	469.3	788.17	1164.92	0.00	-376.75	145545	.8147
126	1.00	207	.514	.519	301.1	726.14	988.43	0.00	-262.29	145382	.8163
127	1.32	231	.494	.467	401.0	819.01	1108.66	0.00	-289.64	145093	.8180
128	1.84	204	.365	.340	499.3	777.13	1178.91	0.00	-401.57	144691	.8196
129	1.11	223	.674	.638	764.0	876.18	992.92	0.00	-116.75	144574	.8213
130	3.80	339	.276	.261	856.0	1213.14	1689.13	0.00	-475.99	144098	.8239

TABLE 11-23.—NETWORK MODEL RESULTS—50-SEAT TILT ROTOR—Concluded

DAILY SUMMARY

Mean utilization, hours	4.52
Standard deviation of utilization, hours	1.691
Distance-weighted load factor	0.482
Nonweighted load factor	0.491
Total passengers carried	108 191
Total direct operating cost, dollars	235 246.13
Total indirect operating cost, dollars	75 524.67
Total revenue, dollars	379 344.52
Total profit, dollars	68 573.72
Mean passenger wait time, min	14.067
Total demand	131 320.0
Percent demand carried	82.39
Total revenue flights	4411
Total distance flown, miles	108 264.6
Total revenue passenger miles flown	2 462 923.6
Number ferry flights	181
Total distance ferried, miles	6044.2
Profit per passenger, dollars	0.634
Fleet size	130
Total gates required	76

TABLE 11-24.—NETWORK MODEL RESULTS—100-SEAT TILT ROTOR

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	5.59	2825	.586	.601	955.9	9888.81	3135.80	0.00	6753.01	6753	.0215
2	6.05	3069	.572	.590	1307.5	10741.54	3352.72	0.00	7388.82	14142	.0449
3	5.63	2732	.592	.581	971.2	9563.66	3144.70	0.00	6418.96	20561	.0657
4	5.21	2315	.524	.526	887.8	8102.94	2984.19	0.00	5118.75	25680	.0823
5	5.36	2397	.555	.545	945.4	8388.24	3017.51	0.00	5370.73	31050	.1016
6	4.58	1906	.521	.515	823.3	6671.77	2684.99	0.00	3986.78	35037	.1161
7	4.53	1958	.517	.515	776.4	6852.72	2695.24	0.00	4157.48	39195	.1310
8	5.08	2149	.483	.478	811.7	7522.59	2977.52	0.00	4545.07	43740	.1474
9	5.10	2267	.568	.591	973.9	7934.25	2847.05	0.00	5087.20	48827	.1646
10	5.32	1896	.430	.471	931.0	6636.31	3009.19	0.00	3627.12	52454	.1791
11	5.40	1925	.424	.428	933.7	6736.37	3048.14	0.00	3688.23	56142	.1937
12	4.86	1675	.412	.429	879.0	5862.09	2792.10	0.00	3069.99	59212	.2065
13	4.46	1716	.466	.464	775.7	6005.97	2657.46	0.00	3348.50	62561	.2195
14	4.08	1303	.384	.395	732.9	4562.23	2483.08	0.00	2079.16	64640	.2295
15	4.56	1711	.472	.462	816.4	5888.53	2581.01	0.00	3307.52	67947	.2425
16	4.47	1488	.448	.425	834.4	5207.04	2616.62	0.00	2590.42	70537	.2538
17	3.17	1318	.430	.424	613.0	3661.57	2176.41	0.00	1485.16	72023	.2516
18	4.77	1410	.402	.381	887.0	4936.53	2719.58	0.00	2216.95	74240	.2723
19	4.98	1292	.331	.349	939.7	4522.09	2752.44	0.00	1769.65	76010	.2822
20	4.64	1376	.372	.397	896.9	4817.71	2652.87	0.00	2164.84	78174	.2926
21	4.19	1086	.363	.350	828.6	3825.16	2463.69	0.00	1361.47	79536	.3009
22	3.45	1080	.412	.360	563.7	3781.27	2272.83	0.00	1508.44	81044	.3091
23	7.32	1968	.320	.328	1293.2	6887.13	3817.37	0.00	3069.76	84114	.3241
24	4.18	1031	.299	.295	720.3	3610.07	2550.59	0.00	1059.48	85174	.3320
25	4.19	1066	.335	.333	801.8	3729.28	2485.59	0.00	1243.70	86417	.3401
26	3.79	1019	.375	.329	670.6	3564.99	2372.18	0.00	1192.82	87610	.3478
27	3.02	736	.317	.320	590.2	2574.39	2020.63	0.00	553.75	88164	.3534
28	4.95	1253	.372	.321	914.7	4384.13	2812.74	0.00	1571.39	89735	.3630
29	5.19	1249	.315	.312	1061.6	4372.79	3010.05	0.00	1362.74	91098	.3725
30	3.76	1035	.330	.357	789.6	3621.42	2441.08	0.00	1180.34	92278	.3804
31	4.93	1106	.299	.299	958.4	3870.73	2800.66	0.00	1070.07	93348	.3888
32	3.60	778	.289	.278	673.6	2723.70	2261.73	0.00	461.96	93810	.3947
33	5.28	1392	.349	.331	1306.6	4871.73	2915.58	0.00	1956.15	95666	.4053
34	5.34	1172	.280	.279	1029.6	4102.42	3028.92	0.00	1073.50	96740	.4143
35	3.45	733	.300	.305	761.3	2671.34	2200.33	0.00	471.01	97211	.4198
36	3.58	865	.291	.309	785.3	3026.52	2438.58	0.00	587.94	97799	.4264
37	3.65	1049	.325	.350	759.5	3669.96	2497.86	0.00	1172.10	98971	.4344
38	5.19	1481	.358	.344	984.9	5183.98	3077.82	0.00	2106.17	101077	.4457
39	3.57	972	.328	.335	755.2	3401.07	2458.55	0.00	942.52	102020	.4531
40	4.67	1095	.291	.288	832.2	3833.66	2727.59	0.00	1106.07	103126	.4614
41	4.02	958	.292	.290	736.1	3353.28	2447.48	0.00	905.80	104032	.4687
42	3.38	892	.331	.330	693.5	3129.73	2319.62	0.00	810.11	104842	.4755
43	3.54	848	.312	.314	679.7	2968.26	2227.84	0.00	740.42	105582	.4820
44	5.08	1094	.272	.281	966.4	3829.31	2842.73	0.00	986.58	106569	.4903
45	3.87	854	.289	.276	704.1	2930.55	2331.60	0.00	598.95	107168	.4968
46	3.35	809	.302	.324	695.1	2831.20	2199.36	0.00	631.84	107799	.5030
47	4.66	967	.260	.255	829.4	3385.78	2725.95	0.00	659.83	108459	.5103
48	3.83	919	.275	.287	738.1	3216.41	2523.49	0.00	692.92	109152	.5173
49	3.52	717	.259	.256	643.4	2509.93	2244.24	0.00	265.69	109418	.5228
50	4.27	942	.276	.277	781.3	3297.84	2548.50	0.00	749.34	110167	.5300
51	4.70	1133	.285	.291	861.8	3966.32	2776.34	0.00	1189.97	111357	.5386
52	4.81	977	.267	.257	927.2	3418.73	2820.01	0.00	598.73	111956	.5460
53	4.35	811	.243	.232	787.9	2836.81	2587.39	0.00	249.41	112205	.5522
54	4.26	739	.215	.231	870.1	2587.34	2501.93	0.00	85.41	112291	.5578
55	3.69	784	.265	.261	659.7	2743.57	2328.43	0.00	415.14	112706	.5638

TABLE 11-24.—NETWORK MODEL RESULTS—100-SEAT TILT ROTOR—Continued

56	4.18	799	.237	.228	717.9	2795.87	2549.13	0.00	246.74	112953	.5699
57	3.64	852	.265	.284	640.8	2982.67	2317.52	0.00	665.15	113619	.5764
58	4.07	793	.254	.256	781.6	2776.37	2436.47	0.00	339.90	113959	.5824
59	4.15	747	.252	.241	817.0	2620.54	2454.63	0.00	165.91	114123	.5881
60	3.95	649	.198	.203	707.5	2272.62	2430.97	0.00	-158.35	113965	.5931
61	3.90	762	.257	.254	739.6	2667.79	2374.73	0.00	293.06	114258	.5989
62	4.81	923	.257	.250	912.9	3232.16	2736.91	0.00	495.25	114753	.6059
63	3.34	573	.221	.212	601.0	2004.38	2182.24	0.00	-177.86	114576	.6102
64	3.24	622	.236	.249	614.4	2176.07	2115.24	0.00	60.83	114636	.6150
65	3.94	667	.200	.196	650.8	2333.48	2472.90	0.00	-139.42	114497	.6201
66	4.36	704	.202	.201	790.5	2464.84	2591.20	0.00	-126.36	114371	.6254
67	4.72	755	.209	.216	928.2	2643.04	2670.99	0.00	-27.95	114343	.6312
68	4.53	839	.225	.227	803.0	2937.79	2673.28	0.00	264.51	114607	.6376
69	3.90	577	.180	.192	740.7	2020.83	2375.38	0.00	-354.54	114253	.6420
70	5.12	681	.159	.162	904.4	2383.47	2919.00	0.00	-535.53	113717	.6471
71	6.38	941	.193	.191	1134.4	3292.72	3426.19	0.00	-133.47	113584	.6543
72	3.56	515	.195	.191	887.1	1843.63	2272.11	0.00	-428.47	113155	.6592
73	5.23	717	.183	.184	1026.0	2507.77	2877.24	0.00	-369.49	112786	.6637
74	4.30	598	.169	.175	792.7	2091.74	2555.13	0.00	-463.35	112322	.6692
75	5.42	771	.191	.197	1071.4	2698.50	2940.90	0.00	-242.40	112080	.6741
76	3.12	603	.221	.241	505.0	2111.77	2147.17	0.00	-35.40	112045	.6787
77	3.17	433	.182	.180	613.2	1515.07	2077.11	0.00	-562.03	111483	.6820
78	4.91	805	.201	.206	976.2	2818.43	2923.17	0.00	-104.74	111378	.6881
79	4.59	613	.190	.196	933.0	2206.70	2598.94	0.00	-392.25	110986	.6928
80	2.83	484	.197	.220	531.1	1694.77	1954.80	0.00	-260.03	110726	.6965
81	3.83	555	.165	.185	712.9	1944.07	2359.25	0.00	-415.20	110311	.7007
82	4.42	499	.148	.151	865.2	1747.38	2559.69	0.00	-812.31	109498	.7045
83	6.61	841	.166	.172	1420.5	2944.72	3591.90	0.00	-647.18	108851	.7109
84	3.86	488	.154	.158	736.0	1709.33	2447.43	0.00	-738.10	108113	.7146
85	4.36	673	.178	.198	932.7	2356.03	2748.36	0.00	-392.32	107720	.7199
86	5.21	644	.169	.157	963.9	2253.32	2916.08	0.00	-662.76	107058	.7247
87	2.59	414	.194	.138	477.8	1448.99	1961.31	0.00	-512.32	106545	.7278
88	4.22	572	.171	.163	773.5	2000.45	2618.74	0.00	-618.30	105927	.7322
89	5.16	616	.149	.150	944.2	2156.82	2904.62	0.00	-747.80	105179	.7369
90	4.33	608	.171	.174	916.5	2126.81	2643.67	0.00	-516.85	104662	.7415
91	3.72	541	.173	.180	749.0	1894.36	2454.41	0.00	-560.05	104102	.7456
92	3.43	422	.173	.194	777.7	1597.48	2172.41	0.00	-574.93	103527	.7488
93	3.10	468	.200	.187	638.3	1638.29	2203.89	0.00	-565.60	102962	.7524
94	3.30	466	.218	.173	623.4	1631.13	2232.61	0.00	-601.48	102360	.7560
95	1.89	421	.326	.281	542.5	1473.06	1886.59	0.00	-413.53	101947	.7592
96	3.80	495	.150	.155	688.6	1733.38	2457.42	0.00	-724.04	101223	.7629

TABLE 11-24.—NETWORK MODEL RESULTS—100-SEAT TILT ROTOR—Concluded

DAILY SUMMARY

Mean utilization, hours	4.33
Standard deviation of utilization, hours	0.889
Distance-weighted load factor	0.298
Nonweighted load factor	0.303
Total passengers carried	100 188
Total direct operating cost, dollars	249 750.67
Total indirect operating cost, dollars	67 784.90
Total revenue, dollars	350 973.41
Total profit, dollars	33 437.84
Mean passenger wait time, min	14.320
Total demand	131 320.0
Percent demand carried	76.29
Total revenue flights	3303
Total distance flown, miles	78 055.8
Total revenue passenger miles flown	2 275 818.3
Number ferry flights	50
Total distance ferried, miles	1754.6
Profit per passenger, dollars	0.334
Fleet size	96
Total gates required	60

TABLE 11-25.—NETWORK MODEL RESULTS—150-SEAT TILT ROTOR

FLIGHT STATISTICS

FLT NBR	HRS UTIL	PAX	WGT L.F.	L.F.	DISTANCE	REVENUE	DOC	IOC	PROFIT	CUM PRO	C.PCNT
1	4.40	2785	.472	.476	726.0	8704.99	3465.22	0.00	5239.77	5281	.0212
2	4.40	2564	.447	.462	814.0	8974.72	3429.68	0.00	5545.04	11026	.0427
3	5.46	2925	.384	.392	911.2	9486.64	4033.19	0.00	5453.45	17679	.0622
4	5.31	2260	.350	.350	985.5	7911.34	3841.91	0.00	4069.43	21749	.0705
5	5.17	2455	.384	.330	957.5	8591.68	3773.51	0.00	4818.17	26567	.0881
6	5.14	2564	.307	.388	880.5	8973.21	3823.09	0.00	5150.12	31717	.1177
7	5.84	2362	.322	.321	1038.6	8266.66	4171.49	0.00	4095.17	35812	.1257
8	4.45	1776	.330	.338	850.5	6041.27	3329.65	0.00	2711.62	38524	.1488
9	4.41	1868	.362	.356	876.7	6537.51	3347.55	0.00	3189.96	41714	.1535
10	4.40	1601	.286	.267	735.8	5503.75	3320.90	0.00	2182.85	43797	.1752
11	3.94	1627	.342	.339	729.1	5693.97	3125.70	0.00	2568.27	46466	.1876
12	5.23	1818	.272	.282	951.8	6761.51	3918.22	0.00	2843.29	49308	.2014
13	4.05	1278	.289	.275	799.1	4473.11	3126.29	0.00	1346.82	51255	.2112
14	3.91	1456	.275	.333	674.5	5095.14	3087.35	0.00	2007.79	52263	.2223
15	5.78	2077	.324	.315	986.6	7267.90	3891.40	0.00	3376.50	55673	.2291
16	3.92	1197	.254	.275	761.7	4191.24	3002.55	0.00	1188.69	56894	.2472
17	3.89	1431	.331	.308	700.7	5008.11	3057.11	0.00	1951.00	58773	.2541
18	6.25	2199	.231	.293	1174.5	7607.53	4217.73	0.00	3389.80	62161	.2748
19	4.84	1472	.255	.258	971.4	5151.63	3560.32	0.00	1591.31	63757	.2860
20	3.85	1167	.249	.251	719.4	4094.46	2979.26	0.00	1115.20	64765	.2949
21	3.55	987	.229	.244	747.4	3454.88	2942.91	0.00	511.97	65277	.3025
22	3.03	1255	.250	.254	697.7	4733.86	3492.12	0.00	1241.74	66519	.3120
23	4.52	1207	.225	.230	881.5	4223.90	3779.05	0.00	444.84	67764	.3212
24	3.93	1275	.263	.257	727.9	4323.71	3122.11	0.00	1201.61	68565	.3306
25	2.99	979	.278	.272	523.3	3426.21	2589.24	0.00	836.97	69492	.3381
26	2.50	762	.250	.267	578.0	2667.85	2483.74	0.00	184.12	69685	.3430
27	3.57	958	.211	.220	698.7	3351.82	3005.99	0.00	344.37	69971	.3512
28	3.96	1069	.222	.230	765.1	3740.98	3162.41	0.00	578.56	70577	.3593
29	2.95	995	.272	.301	673.1	3481.11	2700.96	0.00	780.15	71350	.3669
30	4.97	1463	.250	.232	874.7	5121.56	3715.28	0.00	1406.28	72756	.3780
31	4.36	1205	.243	.244	870.4	4219.83	3277.81	0.00	942.02	73311	.3872
32	2.84	809	.222	.225	500.8	2831.88	2575.55	0.00	256.33	73568	.3934
33	4.50	1273	.223	.222	821.4	4715.15	3434.21	0.00	380.35	74873	.4027
34	3.91	1077	.225	.216	688.6	3770.40	3146.04	0.00	624.37	75467	.4109
35	3.14	875	.219	.224	566.5	3061.12	2719.19	0.00	341.92	75806	.4176
36	3.36	968	.232	.220	573.4	2901.73	2379.17	0.00	521.56	76427	.4252
37	3.09	757	.188	.211	615.7	2636.37	2753.78	0.00	-117.41	76310	.4309
38	4.50	1141	.219	.217	871.9	3891.77	3372.29	0.00	519.48	76829	.4396
39	7.38	1643	.170	.180	1337.4	5749.14	4966.15	0.00	782.99	77712	.4521
40	3.93	980	.201	.211	752.9	3421.61	3053.83	0.00	375.77	78047	.4596
41	3.00	779	.235	.236	620.1	2764.58	2562.00	0.00	202.58	78250	.4655
42	4.84	1089	.190	.191	929.3	3812.59	3558.84	0.00	253.75	78504	.4738
43	4.29	1207	.223	.224	751.2	4226.04	3343.15	0.00	882.89	78787	.4830
44	5.06	1089	.163	.169	884.4	3810.10	3779.80	0.00	30.30	79425	.4913
45	3.13	927	.206	.238	564.1	3245.73	2717.48	0.00	528.25	79954	.4984
46	4.49	992	.183	.134	847.6	3471.06	3401.11	0.00	69.95	80024	.5059
47	3.06	761	.209	.211	588.7	2662.79	2637.37	0.00	25.42	80049	.5117
48	3.37	617	.162	.158	650.4	2161.14	2784.47	0.00	-623.34	79426	.5164
49	3.73	890	.202	.191	672.7	3115.58	3037.43	0.00	78.15	79504	.5232
50	3.86	849	.179	.189	830.8	2971.85	3197.27	0.00	-225.47	79279	.5297
51	3.90	820	.172	.182	725.6	2970.38	3125.97	0.00	-155.59	79123	.5350
52	3.09	615	.193	.178	559.8	2171.51	2593.44	0.00	-421.93	78705	.5406
53	7.16	1352	.159	.151	1381.0	4733.40	4753.24	0.00	-19.84	78685	.5509
54	6.04	1221	.149	.151	1746.0	4274.33	4631.04	0.00	-356.71	78328	.5592
55	2.88	719	.203	.200	554.5	2517.89	2662.04	0.00	-144.15	78184	.5657

TABLE 11-25.—NETWORK MODEL RESULTS—150-SEAT TILT ROTOR—Continued

56	5.44	1051	.154	.156	982.6	3678.74	3937.27	0.00	-258.53	77925	.5737
57	6.55	1212	.150	.152	1257.3	4242.31	4520.11	0.00	-277.80	77647	.5829
58	5.99	1154	.156	.157	1036.9	4038.94	4212.45	0.00	-173.51	77474	.5917
59	6.47	1262	.159	.159	1344.2	4417.37	4776.09	0.00	-359.75	77115	.6013
60	4.86	937	.161	.152	940.2	3280.57	3810.05	0.00	-529.48	76586	.6084
61	3.95	750	.148	.152	747.8	2624.90	3236.35	0.00	-511.45	75974	.6141
62	4.44	917	.176	.174	848.6	3195.60	3355.93	0.00	-160.33	75914	.6211
63	4.25	712	.130	.136	771.1	2490.58	3301.43	0.00	-810.85	75303	.6265
64	4.91	953	.167	.159	903.6	3334.21	3638.17	0.00	-303.96	74509	.6339
65	3.35	743	.155	.177	597.1	2601.72	2838.09	0.00	-236.37	74463	.6394
66	6.16	1054	.149	.153	1286.8	3689.28	4248.47	0.00	-559.19	73904	.6475
67	4.74	858	.158	.147	864.9	3002.43	3562.25	0.00	-559.81	73744	.6540
68	4.25	707	.160	.155	840.6	2791.18	3350.34	0.00	-559.15	72785	.6601
69	4.57	726	.134	.131	848.3	2542.36	3453.18	0.00	-910.82	71374	.6656
70	4.08	623	.122	.126	759.0	2178.91	3195.53	0.00	-1016.62	70857	.6703

TABLE 11-25.—NETWORK MODEL RESULTS—150-SEAT TILT ROTOR—Concluded

DAILY SUMMARY

Mean utilization, hours	4.41
Standard deviation of utilization, hours	1.099
Distance-weighted load factor	0.231
Nonweighted load factor	0.235
Total passengers carried	88 029
Total direct operating cost, dollars	237 299.82
Total indirect operating cost, dollars	62 601.56
Total revenue, dollars	308 157.00
Total profit, dollars	8255.62
Mean passenger wait time, min	14.247
Total demand	131 320.0
Percent demand carried	67.03
Total revenue flights	2500
Total distance flown, miles	58 013.1
Total revenue passenger miles flown	1 990 222.7
Number ferry flights	19
Total distance ferried, miles	565.5
Profit per passenger, dollars	0.094
Fleet size	70
Total gates required	53

TABLE 11-26.—RESULTS OF NETWORK MODEL—1980

1975 aircraft Type		System parameters[a]			
		Person-trips via air mode			
Type	No. of seats	Daily, thousands	% of mode-split demand	Fleet size[b]	Gates
Helicopter	50	52.5	78.1	77	49
	98	46.8	69.6	63	45
	150	38.1	56.7	39	36
Augmentor wing STOL	49	48.6	80.8	75	48
	95	40.8	67.9	49	39
	153	36.1	60.0	35	37

[a]Based on 1980 passenger demand
[b]Includes 2% spare aircraft

TABLE 11-27.—ESTIMATED 1975 AIRCRAFT PRICES

1975 aircraft		Unit price, millions of 1970 $				
Type	No. of seats	Airframe	Electronics	Engines	Spares per aircraft[a]	Total
Helicopter	50	1.144	0.305	0.228	0.104	1.781
	98	1.687	0.305	0.355	0.151	2.498
	150	2.135	0.305	0.452	0.188	3.080
Augmentor wing STOL	49	.816	0.305	0.438	0.132	1.691
	95	1.118	0.305	0.545	0.166	2.134
	153	1.482	0.305	0.685	0.208	2.680

[a]Based on 20% engine spares and 4% airframe and electronics spares

TABLE 11-28.—REQUIRED INITIAL INVESTMENTS—1975[a]

1975 aircraft		Initial investments, millions of 1970 $			
			Air terminals[b]		
Type	No. of seats	Aircraft[c]	Land	Facilities	Total
Helicopter	50	137	13	242	392
	98	158	19	251	428
	150	120	21	246	387
Augmentor wing STOL	49	127	169	432	728
	95	104	179	439	722
	153	94	189	451	734

[a]1975 investment for an air transportation system that would accommodate 1980 passenger demand
[b]See section 8.4.9; facilities include all air terminal nonland costs plus maintenance facility costs
[c]Includes 20% engine spares, 4% airframe and electronics spares, and 2% spare aircraft

TABLE 11-29.—1980 ANNUAL SYSTEM LOSSES
(Millions of 1970 dollars)

1975 aircraft		Sinking fund deposits[a]				
Type	No. of seats	6% interest cost on total investment[b]	Operating loss[c]	Aircraft and spares[d]	Terminal facilities[e]	Total
Helicopter	50	24	0	9	7	40
	98	26	7	11	8	52
	150	23	8	8	7	46
Augmentor wing STOL	49	44	-4	9	13	62
	95	43	-3	7	13	60
	153	44	2	6	14	66

[a]Capital recovery accumulation to be reinvested in asset replacements
[b]Assumes total investment is financed by municipal government bonds
[c]Does not include depreciation charges against aircraft or terminals (negative loss means profit)
[d]10-year life; salvage value = 15% of initial cost; interest rate = 5% compunded annually
[e]20-year life; salvage value = 0; interest rate = 5% compunded annually

TABLE 11-30.—1980 ANNUAL SYSTEM LOSSES PER PERSON
(1970 Dollars)

1975 aircraft				
Type	No. of seats	Loss per person in 1980 bay area population[a]	Loss per person 18 years of age and over[b]	Loss per air person-trip[c]
Helicopter	50	$ 6.40	$10.10	$2.45
	98	8.40	13.10	3.55
	150	7.40	11.60	3.85
Augmentor wing STOL	49	10.00	15.60	4.05
	95	9.70	15.10	4.70
	153	10.60	16.60	5.80

[a]1980 population = 6.2 million (p. 38, ref. 2)
[b]In 1966, the population ratio of persons 18 years and over to total U.S. population was 126.2M/196.8M = 64% (see p. 262, 1968 World Almanac)
[c]Assumes 314 equivalent operating days per year

TABLE 11-31.—RESULTS OF NETWORK MODEL—1990

1985 aircraft		System parameters[a]			
		Person-trips via air mode			
Type	No. of seats	Daily, thousands	% of mode-split demand	Fleet size[b]	Gates
Helicopter	50	92.6	79.9	122	67
	98	86.7	74.8	96	55
	150	74.2	64.1	68	49
Augmentor wing STOL	49	79.7	82.4	113	64
	95	71.5	74.0	76	54
	153	63.8	66.1	59	49
Tilt-rotor VTOL	50	108.2	82.4	133	76
	100	100.2	76.3	98	60
	150	88.0	67.0	72	53

[a]Based on 1990 passenger demand
[b]Includes 2% spare aircraft

TABLE 11-32.—ESTIMATED 1985 AIRCRAFT PRICES

1985 aircraft		Unit price, millions of 1970 $				
Type	No. of seats	Airframe	Electronics	Engines	Spares per aircraft[a]	Total
Helicopter	50	1.144	0.305	0.211	0.100	1.760
	98	1.687	0.305	0.331	0.146	2.469
	150	2.135	0.305	0.441	0.186	3.067
Augmentor wing STOL	49	0.835	0.305	0.430	0.132	1.702
	95	1.127	0.305	0.531	0.163	2.126
	153	1.478	0.305	0.663	0.204	2.650
Tilt-rotor VTOL	50	1.018	0.305	0.239	0.101	1.663
	100	1.641	0.305	0.377	0.153	2.476
	150	2.176	0.305	0.488	0.197	3.166

[a]Based on 20% engine spares and 4% airframe and electronics spares

TABLE 11-33.—REQUIRED INITIAL INVESTMENTS—1985[a]

1985 aircraft		Initial investments, millions of 1970 $			
			Air terminals[b]		
Type	No. of seats	Aircraft[c]	Land	Facilities	Total
Helicopter	50	215	30	278	523
	98	237	40	279	556
	150	232	49	283	564
Augmentor wing STOL	49	192	308	485	985
	95	161	325	487	973
	153	156	342	494	992
Tilt-rotor VTOL	50	221	36	297	554
	100	243	46	293	582
	150	228	55	300	583

[a]1985 investment for an air transportation system which would accommodate 1980 passenger demand
[b]See section 8.4.9; facilities include all air terminal nonland costs plus maintenance facility costs
[c]Includes 20% engine spares, 4% airframe and electronic spares, and 2% spare aircraft

TABLE 11-34.—1990 ANNUAL SYSTEM LOSSES[a]
(Millions of 1970 Dollars)

1985 aircraft		Sinking fund deposits				
Type	No. of seats	6% interest cost on total investment[b]	Operating loss[c]	Aircraft and spares[d]	Terminal facilities[e]	Total
Helicopter	50	31	-26	15	8	28
	98	33	-17	16	8	40
	150	34	- 9	16	9	50
Augmentor wing STOL	49	59	-23	13	15	69
	95	58	-20	11	15	64
	153	59	-13	11	15	72
Tilt-rotor VTOL	50	33	-44	15	9	13
	100	35	-34	16	9	26
	150	35	-24	15	9	35

[a]Capital recovery accumulation to be reinvested in asset replacements
[b]Assumes total investment is financed by municipal government bonds
[c]Does not include depreciation charges against aircraft or terminals (negative loss means profit)
[d]10-year life; salvage value = 15% of initial cost; interest rate = 5% compounded annually
[e]20-year life; salvage value = 0; interest rate = 5% compounded annually

TABLE 11-35.—1990 ANNUAL SYSTEM LOSSES PER PERSON
(1970 Dollars)

1985 aircraft		Loss per person in 1990 bay area population[a]	Loss per person 18 years of age and over[b]	Loss per air person-trip
Type	No. of seats			
Helicopter	50	3.75	5.85	.95
	98	5.35	8.35	1.45
	150	6.65	10.40	2.15
Augmentor wing STOL	49	8.55	13.35	2.55
	95	8.55	13.35	2.85
	153	9.60	15.00	3.60
Tilt-rotor VTOL	50	1.75	2.70	0.40
	100	3.45	5.40	0.80
	150	4.65	7.25	1.25

[a] 1990 population = 7.5 million (p. 43, ref. 2)

[b] In 1966, the population ratio of persons 18 years and over to total U.S. population was 126.2M/198.6M = 64% (see p. 262, 1968 World Almanac)

TABLE 11-36.—SOURCES AND APPLICATIONS OF FUNDS—1980
50-SEAT HELICOPTER SYSTEM
(Millions of 1970 Dollars)

Funds	Possible cash flows A	B	C	D	E
Long-term debt:					
Required investment	392	392	392	392	392
Less: federal grant	0	0	0	-261	-261
30-year municipal bond debt	392	392	392	131	131
Sources of funds:					
Operating profit	0	0	0	0	0
Concessions/leases	0	11	22	7	7
Federal subsidy	0	0	0	0	9.5
Local Subsidy	46	35	24	19	9.5
	46	46	46	26	26
Applications of funds:					
6% bond interest	24	24	24	8	8
Sinking funds at 5%					
Asset replacement	16	16	16	16	16
Debt retirement	6	6	6	2	2
	46	46	46	26	26

TABLE 11-37.–SOURCES AND APPLICATIONS OF FUNDS–1990 50-SEAT TILT-ROTOR VTOL SYSTEM
(Millions of 1970 Dollars)

Funds	Possible cash flows				
	A	B	C	D	E
Long-term debt:					
Required investment	554	554	554	554	554
Less: federal grant	0	0	0	-370	-370
30-year municipal bond debt	554	554	554	184	184
Sources of funds:					
Operating profit	44	44	44	44	44
Concessions/Leases	0	14.5	29	8	8
Federal subsidy	0	0	0	0	0
Local subsidy	21	6.5	0	0	0
	65	65	73	52	52
Applications of funds:					
6% bond interest	33	33	33	11	11
Sinking funds at 5%					
Asset replacement	24	24	24	24	24
Debt retirement	8	8	8	3	3
	65	65	65	38	38
Surplus	0	0	8	14	14

TABLE 11-38.–SOURCES AND APPLICATIONS OF FUNDS–1980 49-SEAT AUGMENTOR WING STOL SYSTEM
(Millions of 1970 Dollars)

Funds	Possible cash flows				
	A	B	C	D	E
Long-term debt:					
Required investment	728	728	728	728	728
Less: federal grant	0	0	0	-485	-485
30-year municipal bond debt	728	728	728	243	243
Sources of funds:					
Operating profit	4	4	4	4	4
Concessions/leases	0	24.5	49	12	12
Federal subsidy	0	0	0	0	12.5
Local Subsidy	73	48.5	24	25	12.5
	77	77	77	41	41
Applications of funds:					
6% bond interest	44	44	44	15	15
Sinking funds at 5%					
Asset replacement	22	22	22	22	22
Debt retirement	11	11	11	4	4
	77	77	77	41	41

TABLE 11-39.–SOURCES AND APPLICATIONS OF FUNDS–1990 49-SEAT AUGMENTOR WING STOL SYSTEM
(Millions of 1970 Dollars)

Funds	Possible cash-flows				
	A	B	C	D	E
Long-term debt:					
Required investment	985	985	985	985	985
Less: federal grant	0	0	0	-657	-657
30-year municipal bond debt	985	985	985	328	328
Source of funds:					
Operating profit	23	23	23	23	23
Concessions/Leases	0	31	62	15	15
Federal subsidy	0	0	0	0	7.5
Local subsidy	79	48	17	15	7.5
	102	102	102	53	53
Applications of funds:					
6% bond interest	59	59	59	20	20
Sinking funds at 5%					
Asset replacement	28	28	28	28	28
Debt retirement	15	15	15	5	5
	102	102	102	53	53

TABLE 11-40.–TOP METROPOLITAN AIR TRANSPORT SYSTEM LINKS IN ORDER OF PROFIT– AUGMENTOR WING STOL

Order	Link nos.	Node	Node
1	1-15	San Francisoc Ferry Bldg	Hayward Airport
2	1-20	San Francisco Ferry Bldg	Buchanan Field
3	1-6	San Francisco Ferry Bldg	San Carlos Airport
4	5-9	San Francisco International Airport	San Jose Municipal Airport
5	1-7	San Francisco Ferry Bldg	Palo Alto Municipal Airport
6	1-16	San Francisco Ferry Bldg	Oakland International Airport
7	1-9	San Francisco Ferry Bldg	San Jose Municipal Airport
8	9-15	San Jose Municipal Airport	Hayward Airport
9	6-9	San Carlos Airport	San Jose Municipal Airport
10	1-30	San Francisco Ferry Bldg	Corte Madera (Marin)
11	9-16	San Jose Municipal Airport	Oakland International Airport
12	5-7	San Francisco International Airport	Palo Alto Municipal Airport
13	1-17	San Francisco Ferry Bldg	Berkeley Waterfront
14	1-29	San Francisoc Ferry Bldg	Gnoss Field (Marin)
15	11-15	Reed Hillview Airport	Hayward Airport

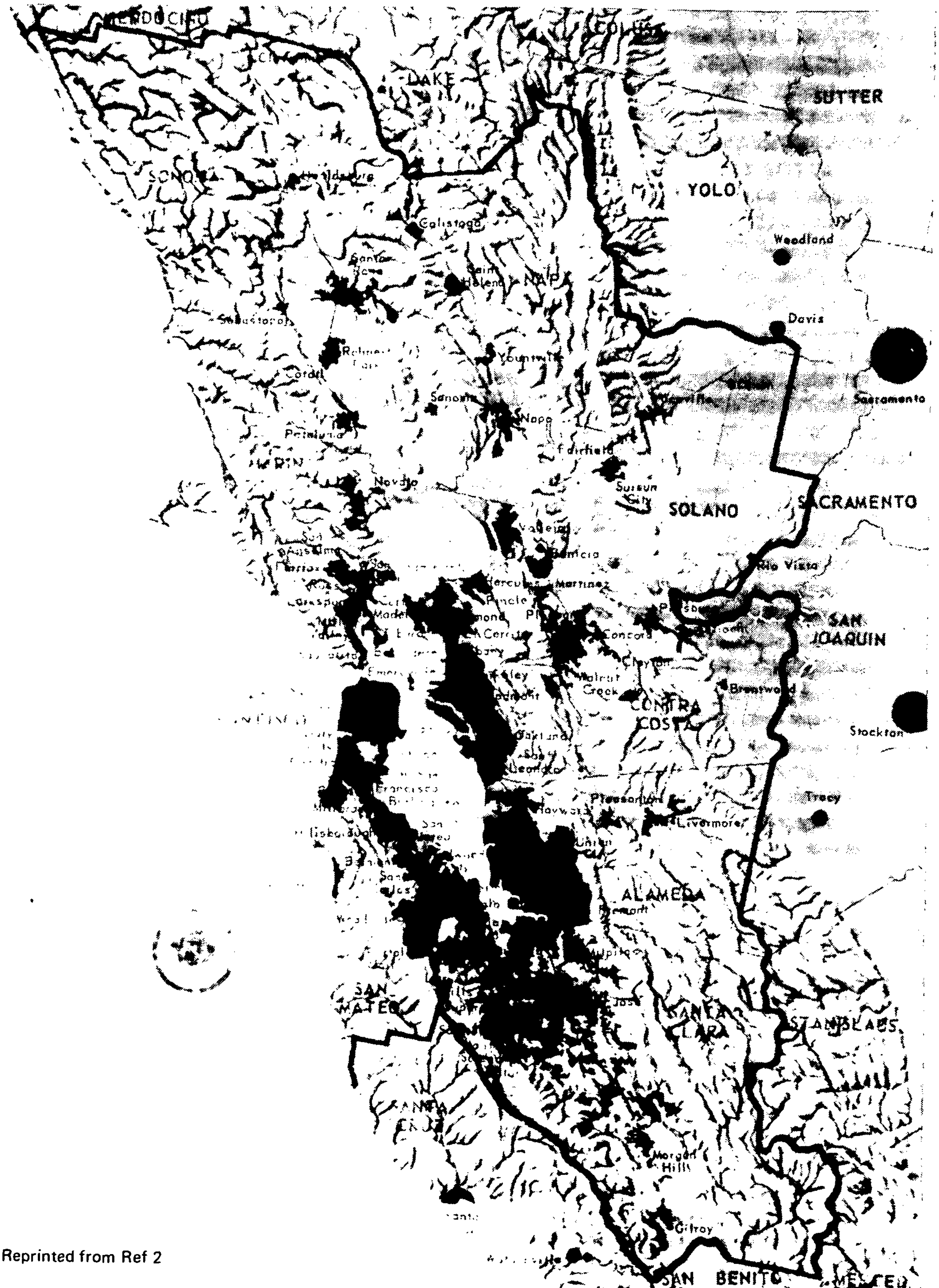


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FIGURE 11-1.—THE NINE-COUNTY SAN FRANCISCO BAY AREA

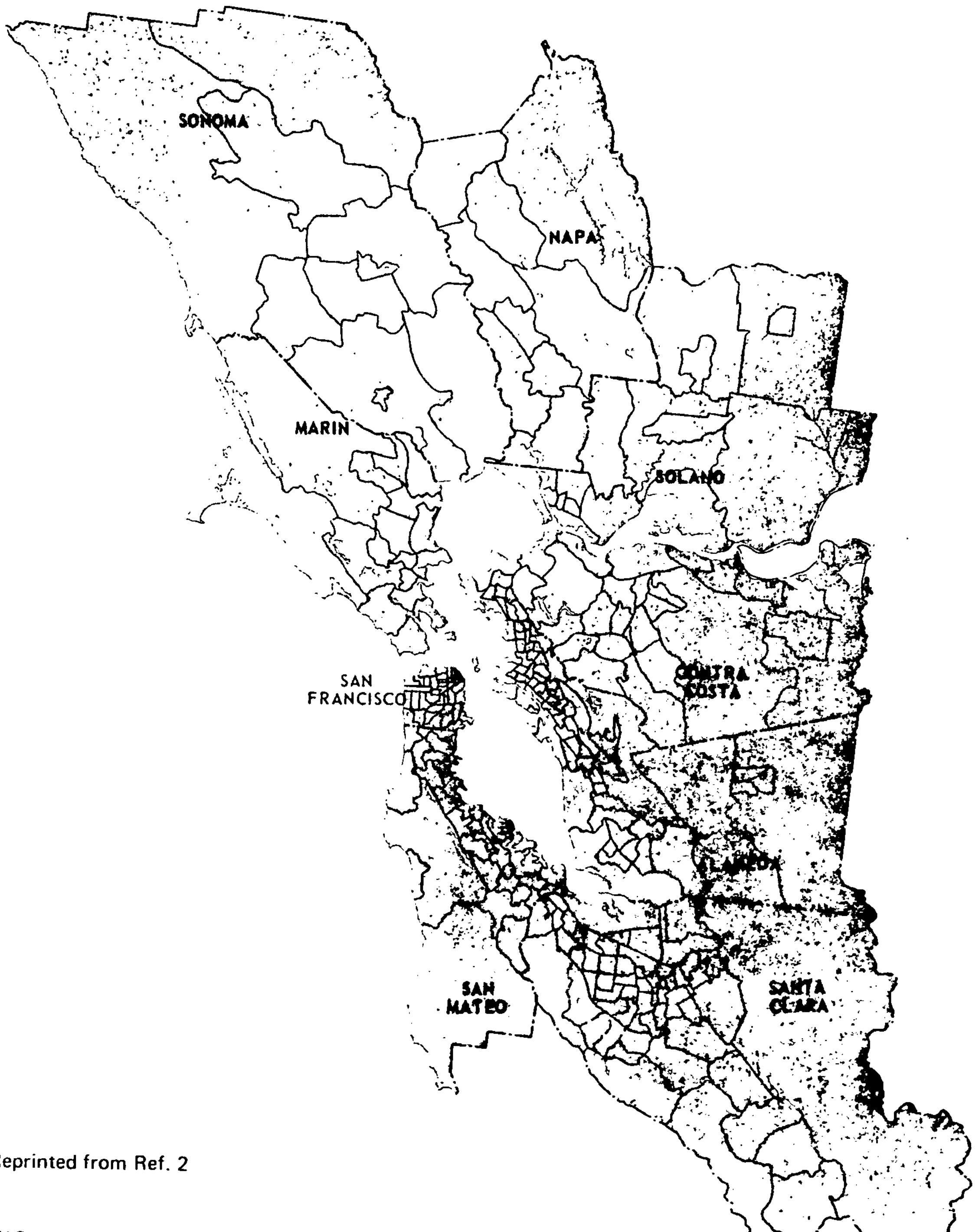

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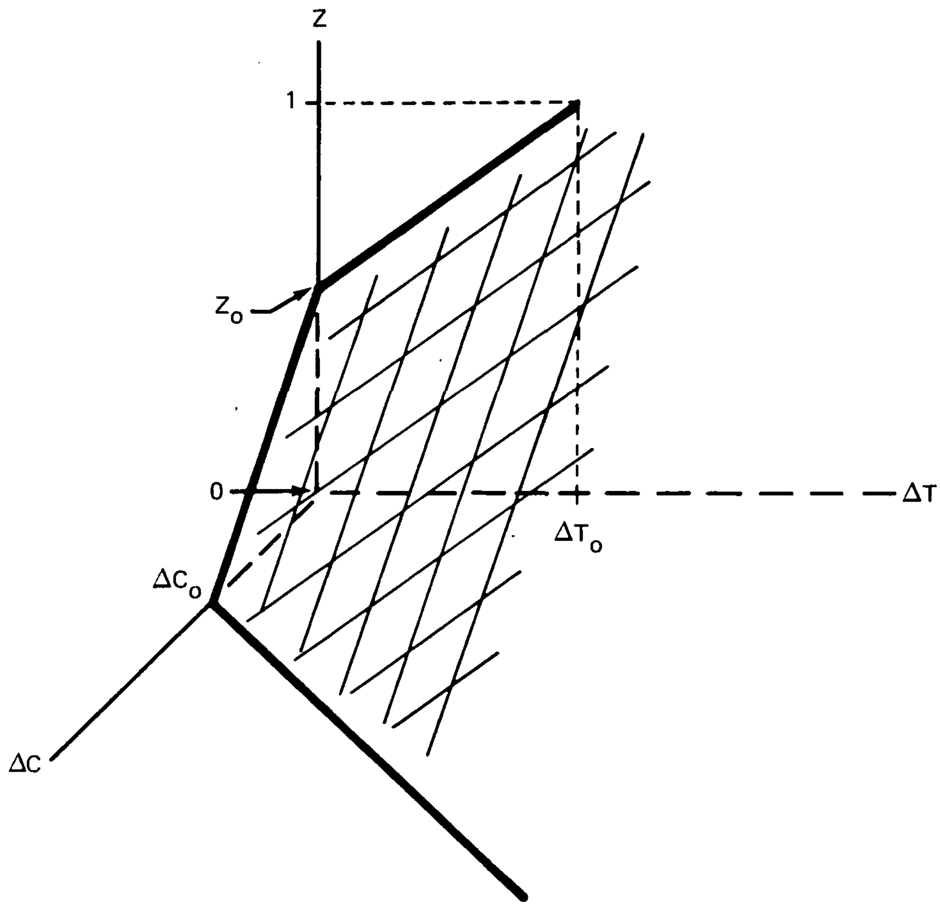
FIGURE 11-2.—ANALYSIS ZONES IN THE STUDY AREA



Z = Decimal fraction of person trips diverted to air from existing mode
ΔC = Air mode door-to-door one-way trip cost minus existing mode cost
ΔT = Existing mode door-to-door one-way trip time minus air mode time

FIGURE 11-3.—MODE SPLIT

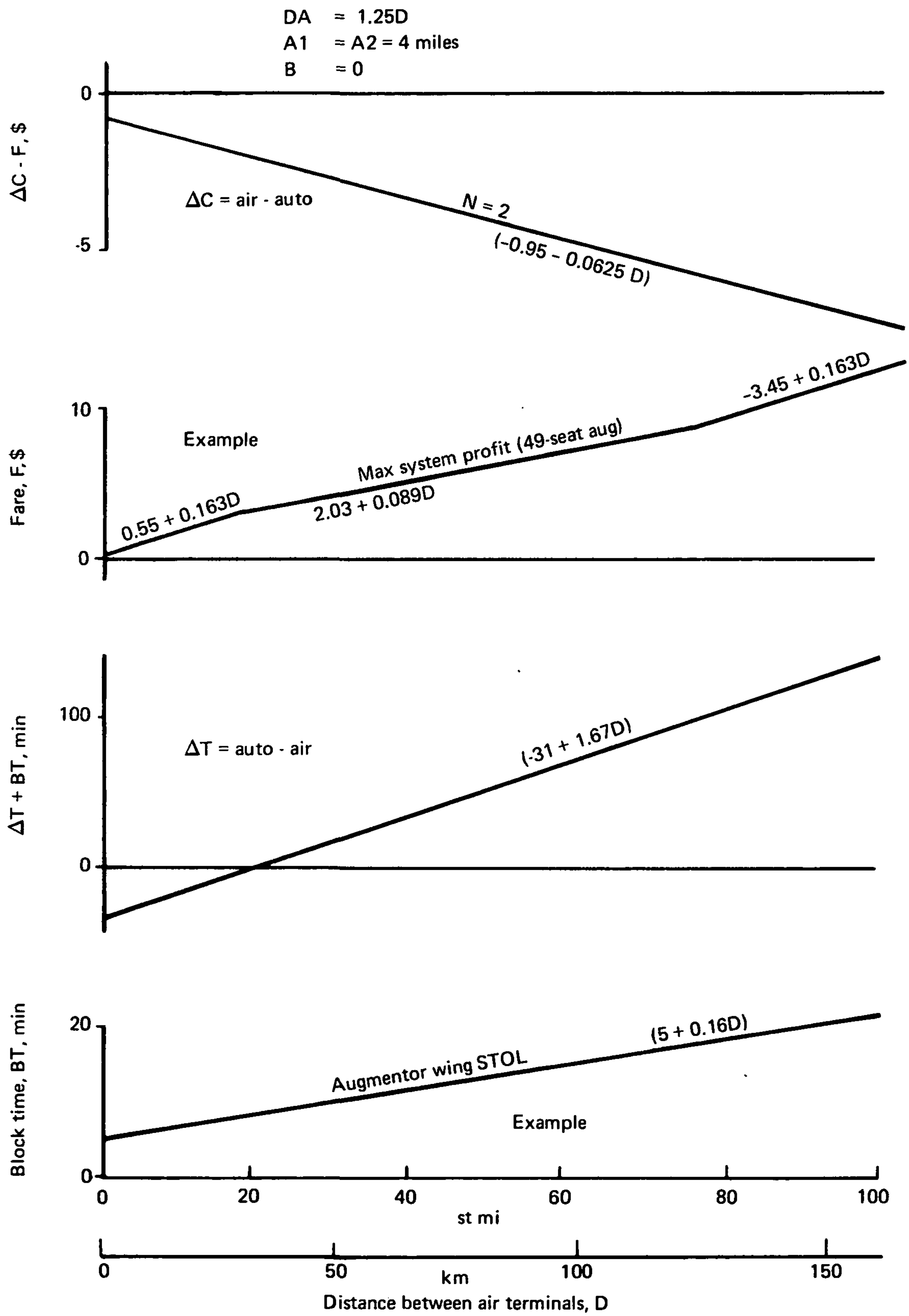
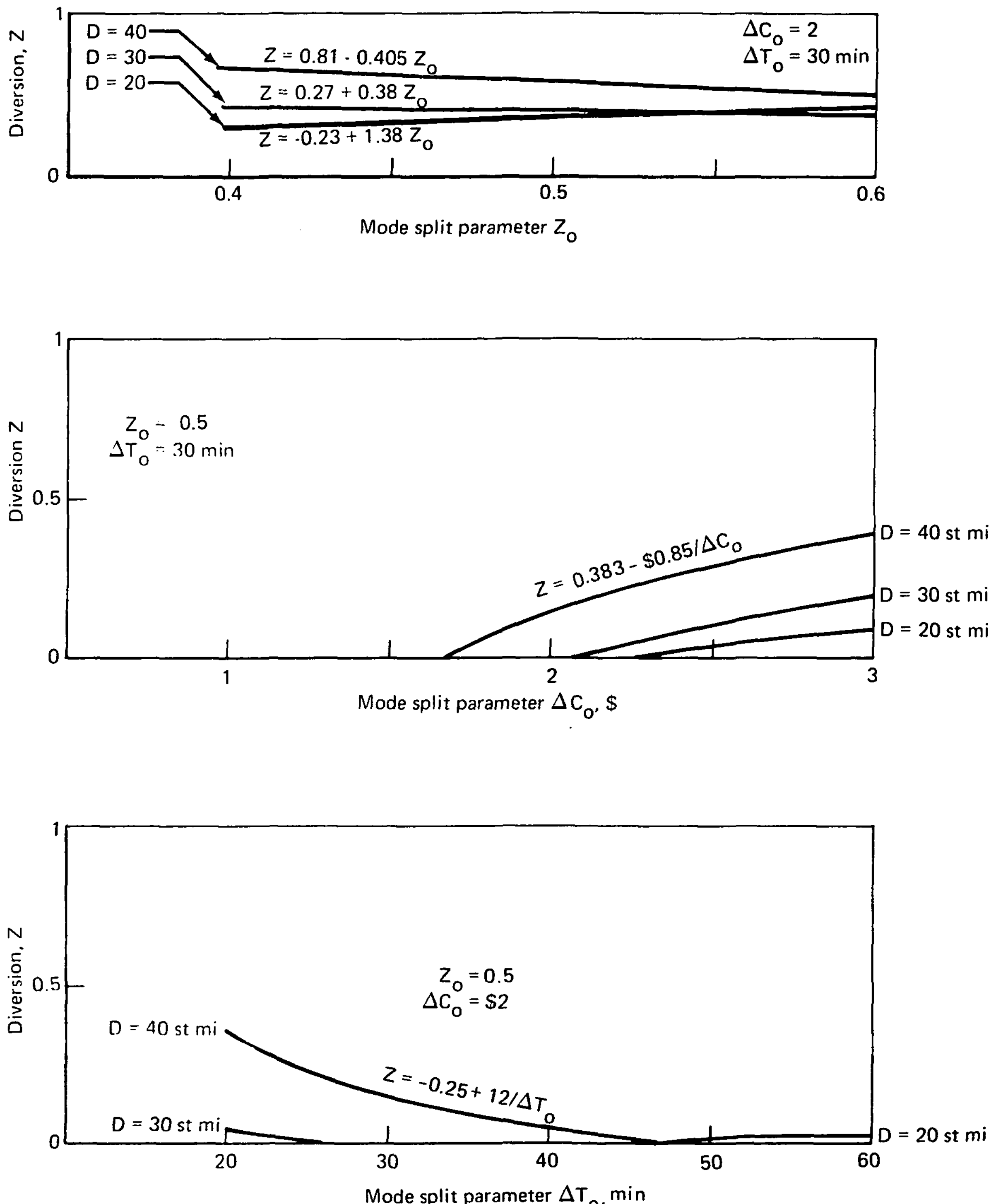


FIGURE 11-4.—MODE SPLIT PARAMETERS

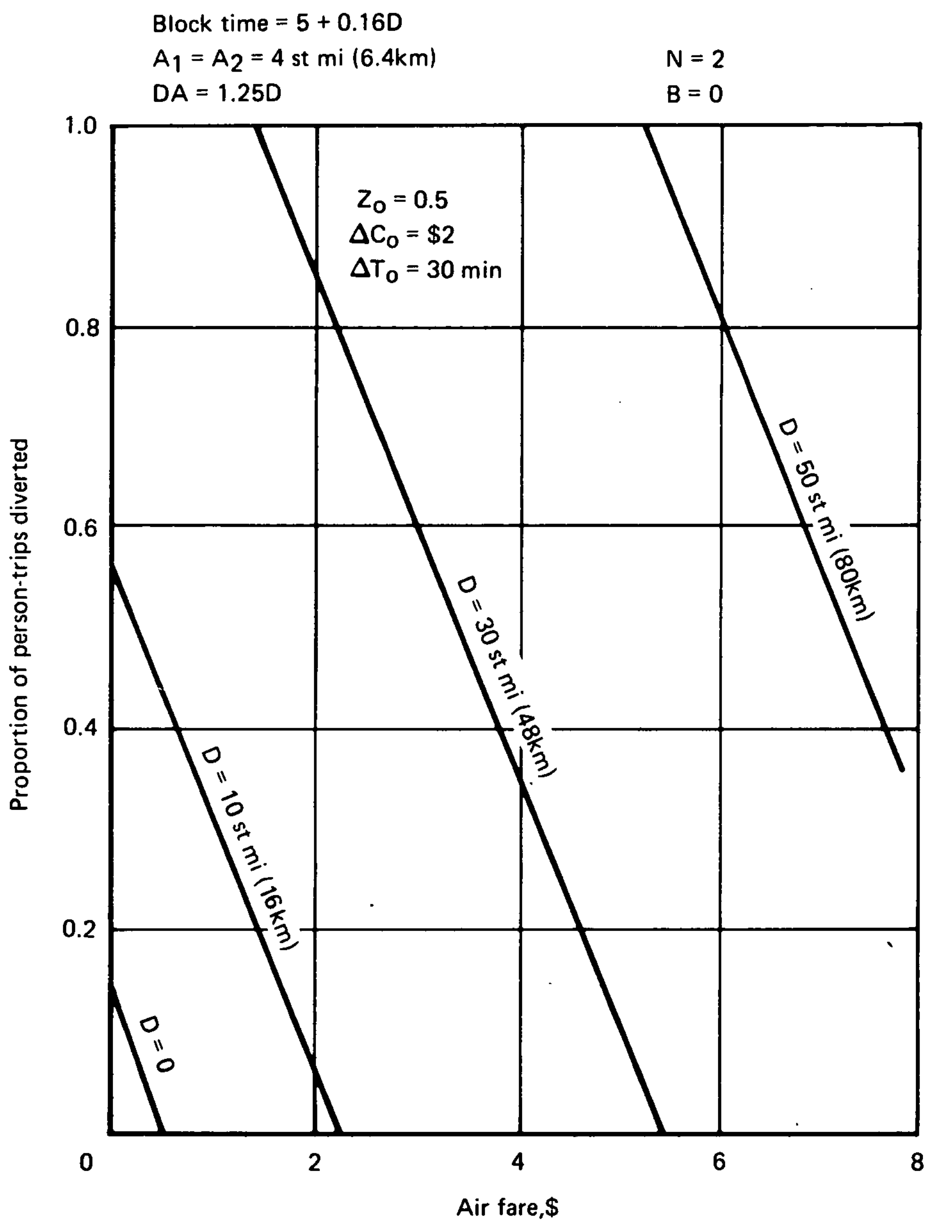


Mode split equation: $Z = Z_o - \left(\frac{Z_o}{\Delta C_o}\right)\Delta C + \left(\frac{1 - Z_o}{\Delta T_o}\right)\Delta T$

D = 20: ΔC = \$ -0.29 ΔT = -7
D = 30: ΔC = 0.71 ΔT = 8
D = 40: ΔC = 1.19 ΔT = 24

Maximum profit fare
DA = 1.25D
A1 = A2 = 4
B = 0
N = 2

FIGURE 11-5.—MODE SPLIT SENSITIVITY TO Z_o, ΔC_o, AND ΔT_o —49-SEAT AUGMENTOR WING STOL



$$Z = 0.5 - 0.25\Delta C + 0.0167\Delta T$$
$$\Delta C = -0.95 - 0.0625D + F$$
$$\Delta T = -36 + 1.51D$$
$$\therefore Z = 0.138 + 0.0408D - 0.25F$$

FIGURE 11-6.—AIR DIVERSION FROM SINGLE-OCCUPANT AUTO

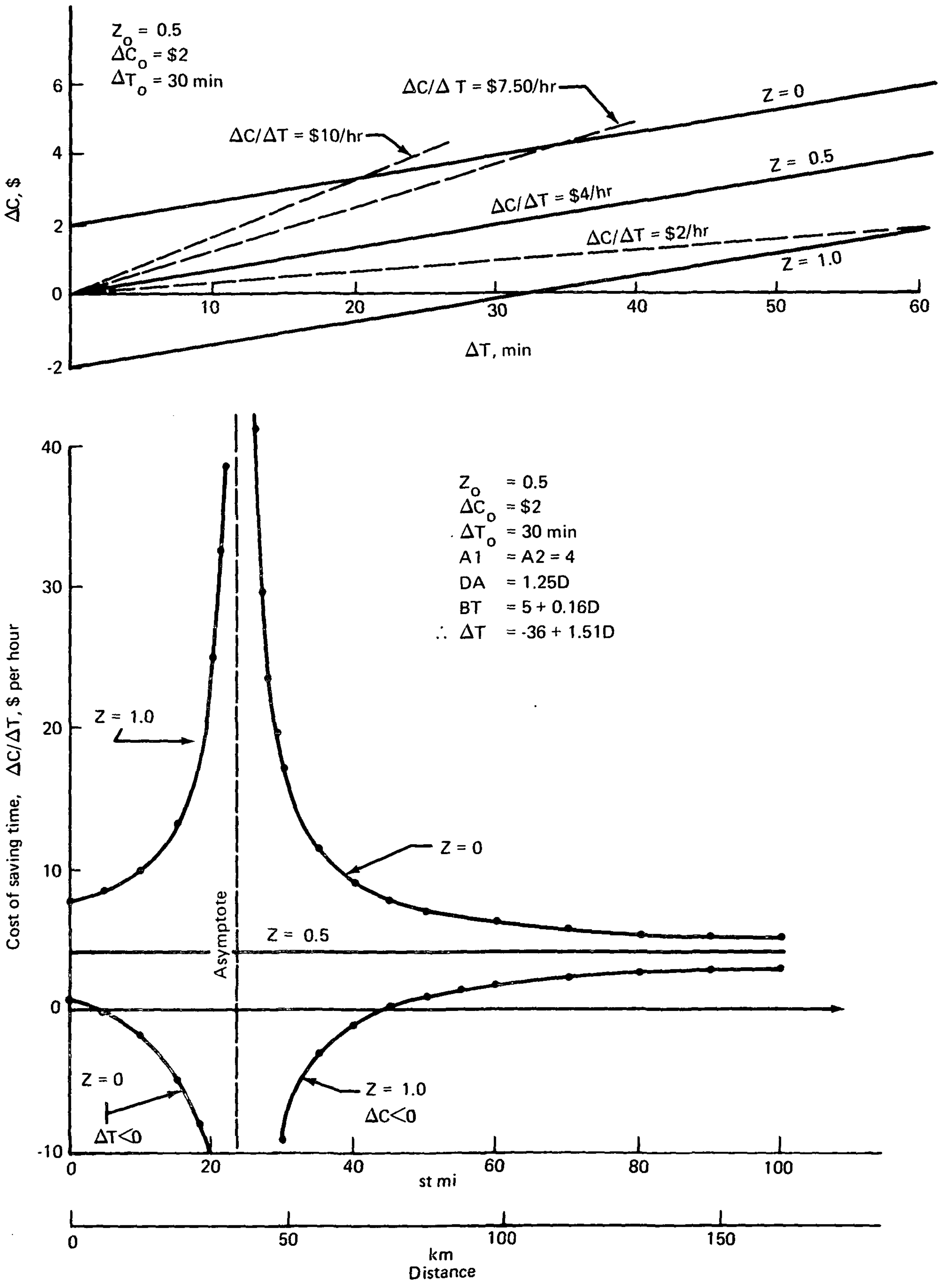


FIGURE 11-7.—MODE SPLIT VALUE OF TIME

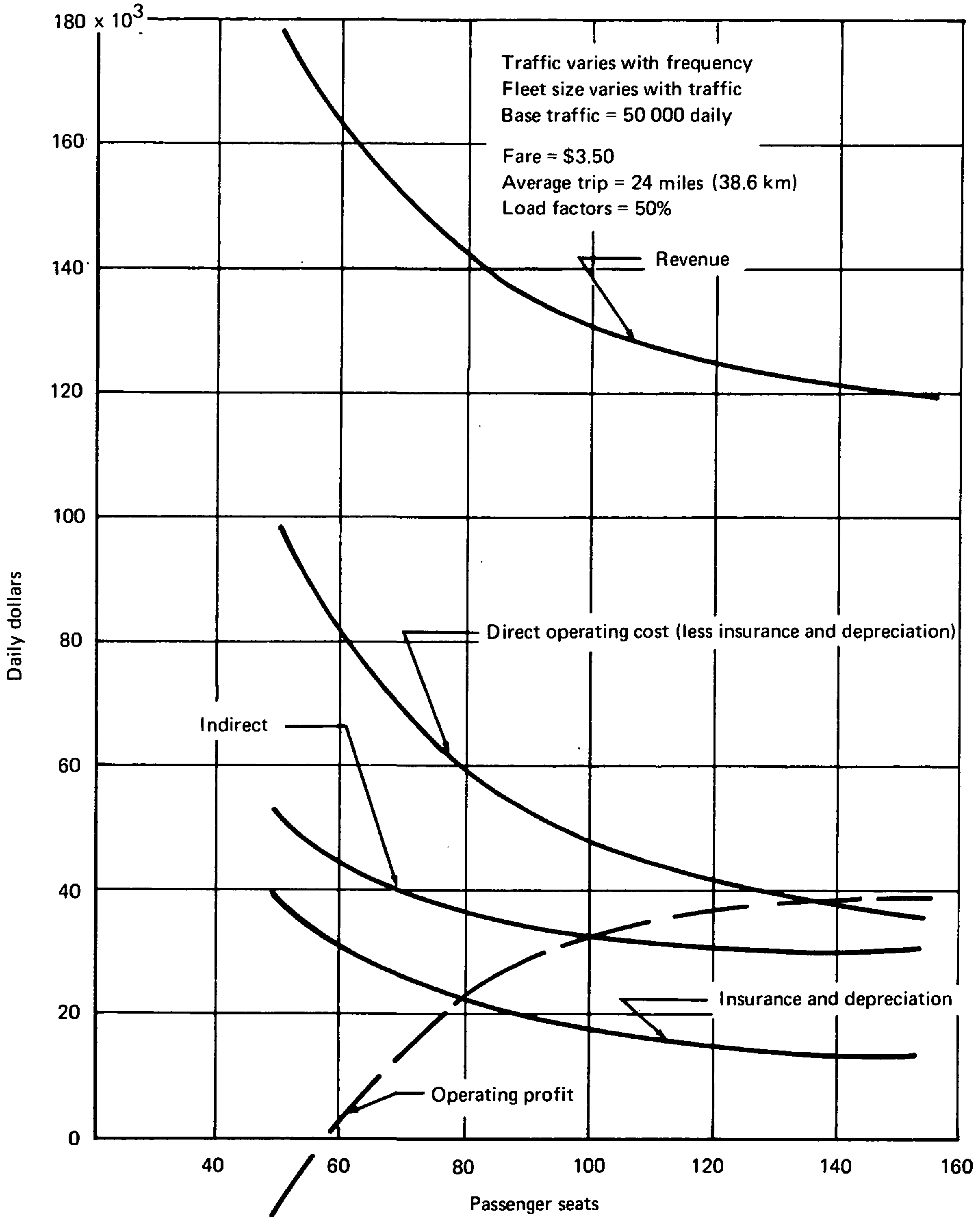


FIGURE 11-8.—AUGMENTOR WING STOL IN METROPOLITAN AIR TRANSPORT

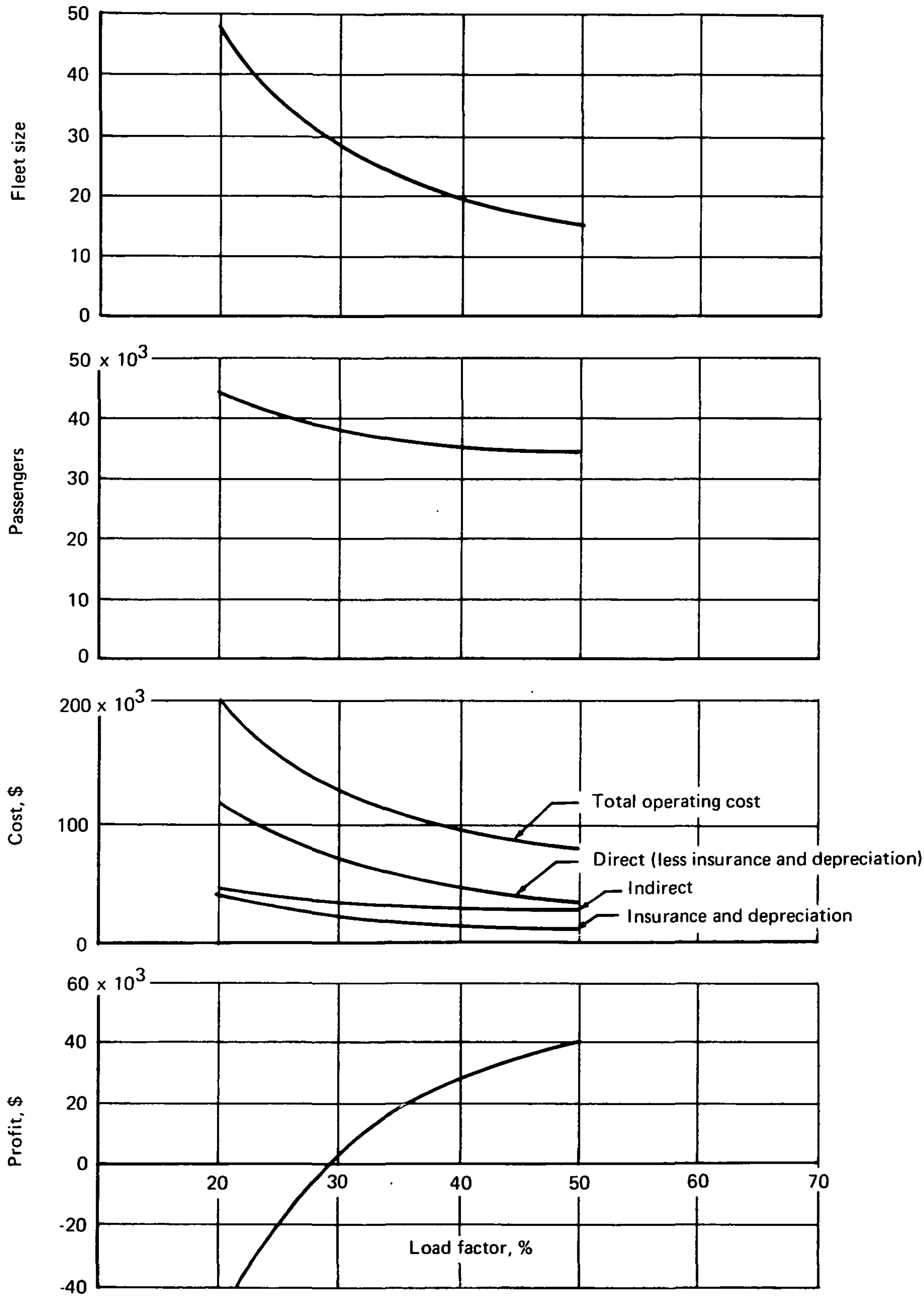


FIGURE 11-9.—ECONOMIC SUMMARY FOR 153-PASSENGER AUGMENTOR WING STOL IN METROPOLITAN AIR TRANSPORT

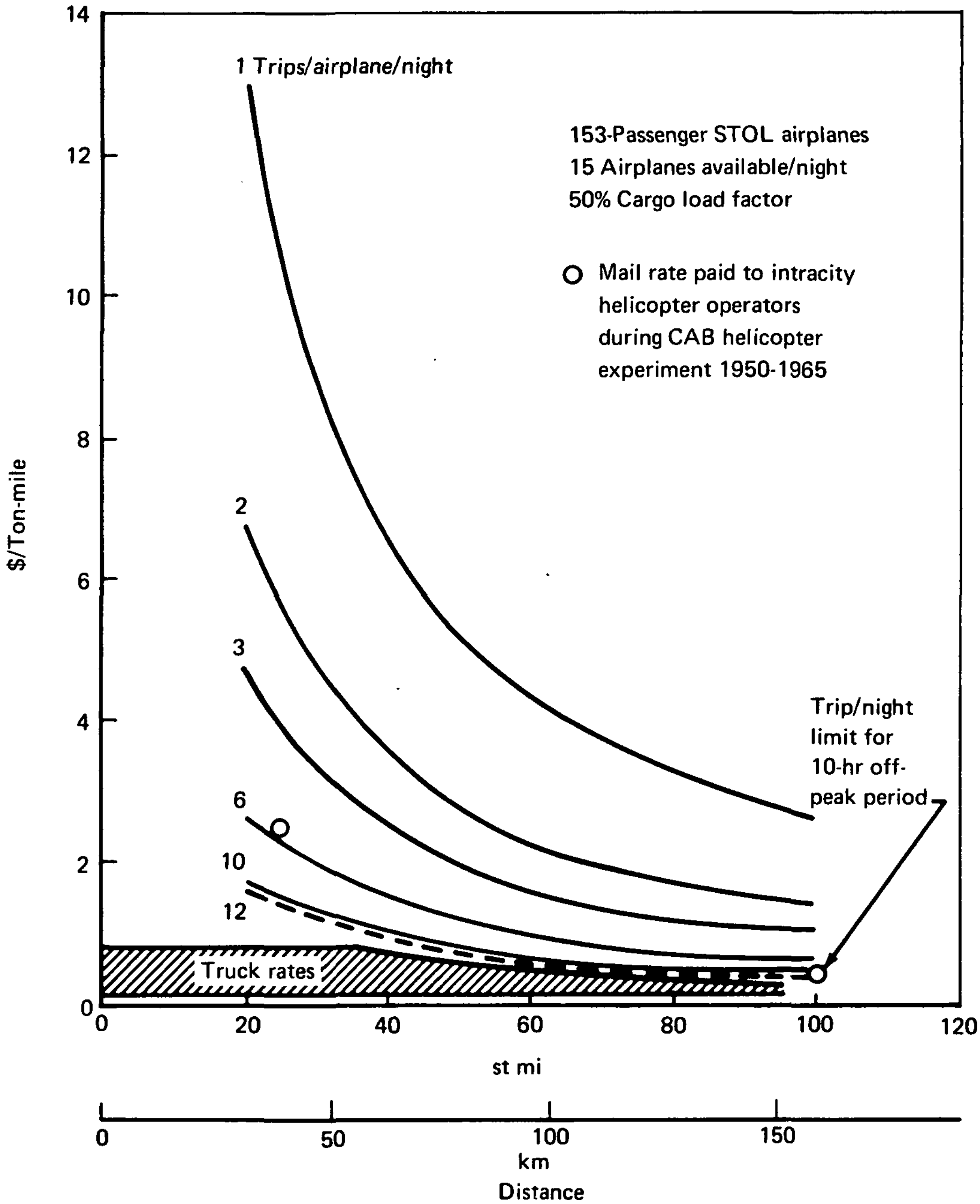


FIGURE 11-10.–TON-MILE REVENUE REQUIRED TO COVER COSTS AND SYSTEM LOSS

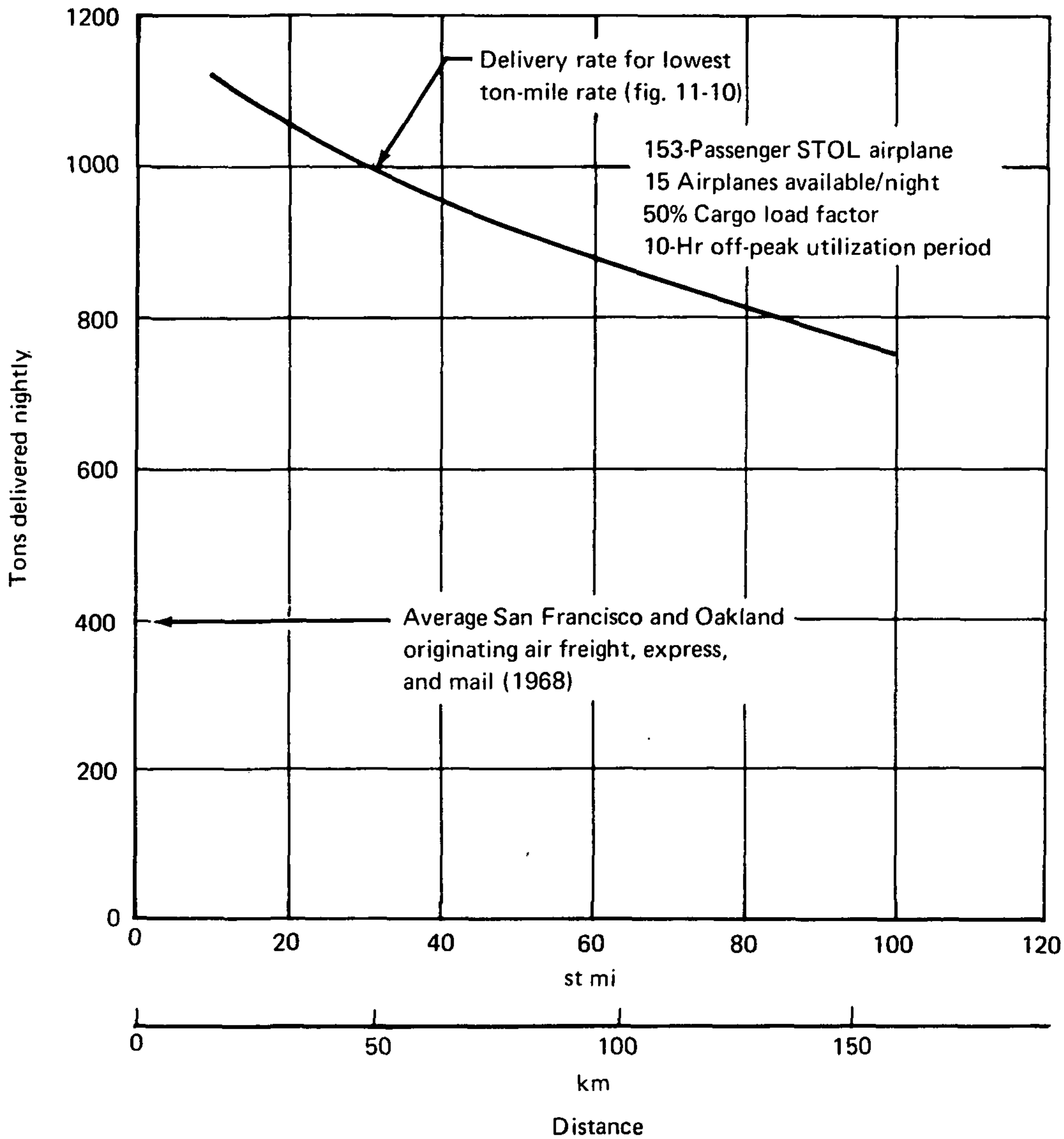
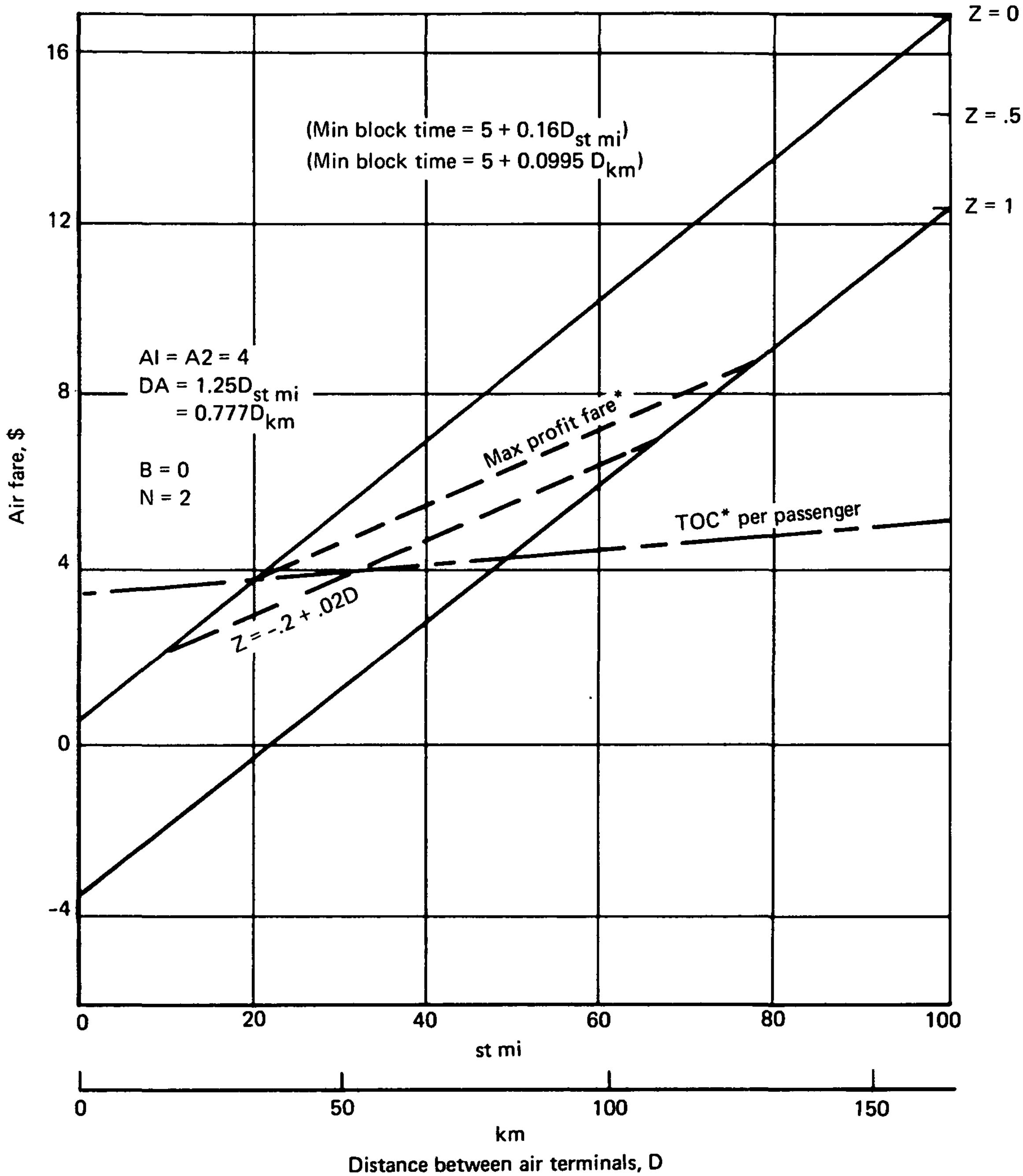


*FIGURE 11-11.—TOTAL DAILY TONNAGE VS AVERAGE DISTANCE—
15 MAT CARGO AIRCRAFT*



*49-seat augmentor wing STOL, LF = 0.5, U = 40 flights/day
Z = Fraction diverted from single-occupant auto travelers

FIGURE 11-12.–STOL AIR FARE VS DISTANCE

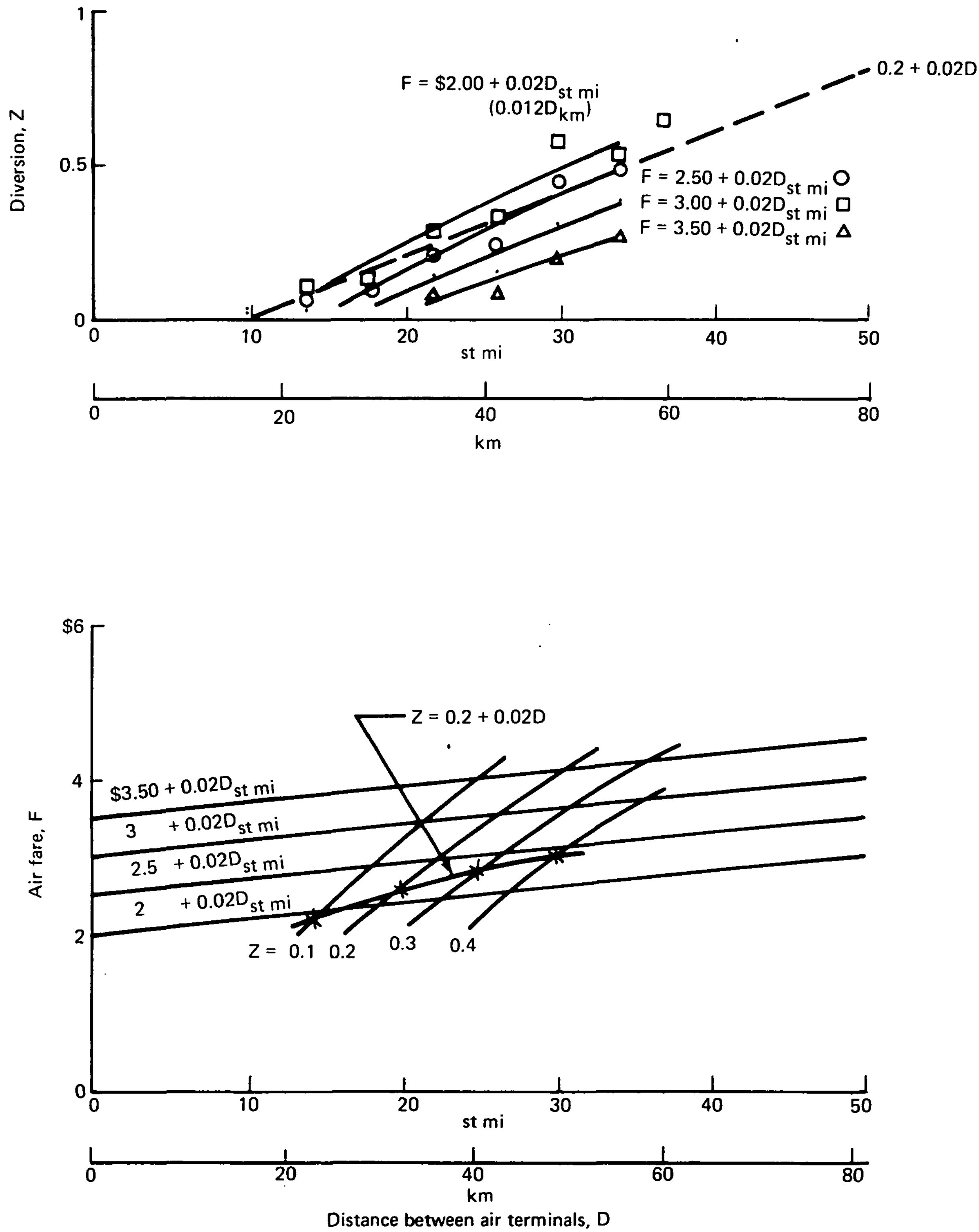


FIGURE 11-13.—EFFECT OF FARE ON PERCENT DIVERSION FROM SINGLE-OCCUPANT AUTO BASE TRAFFIC—1980

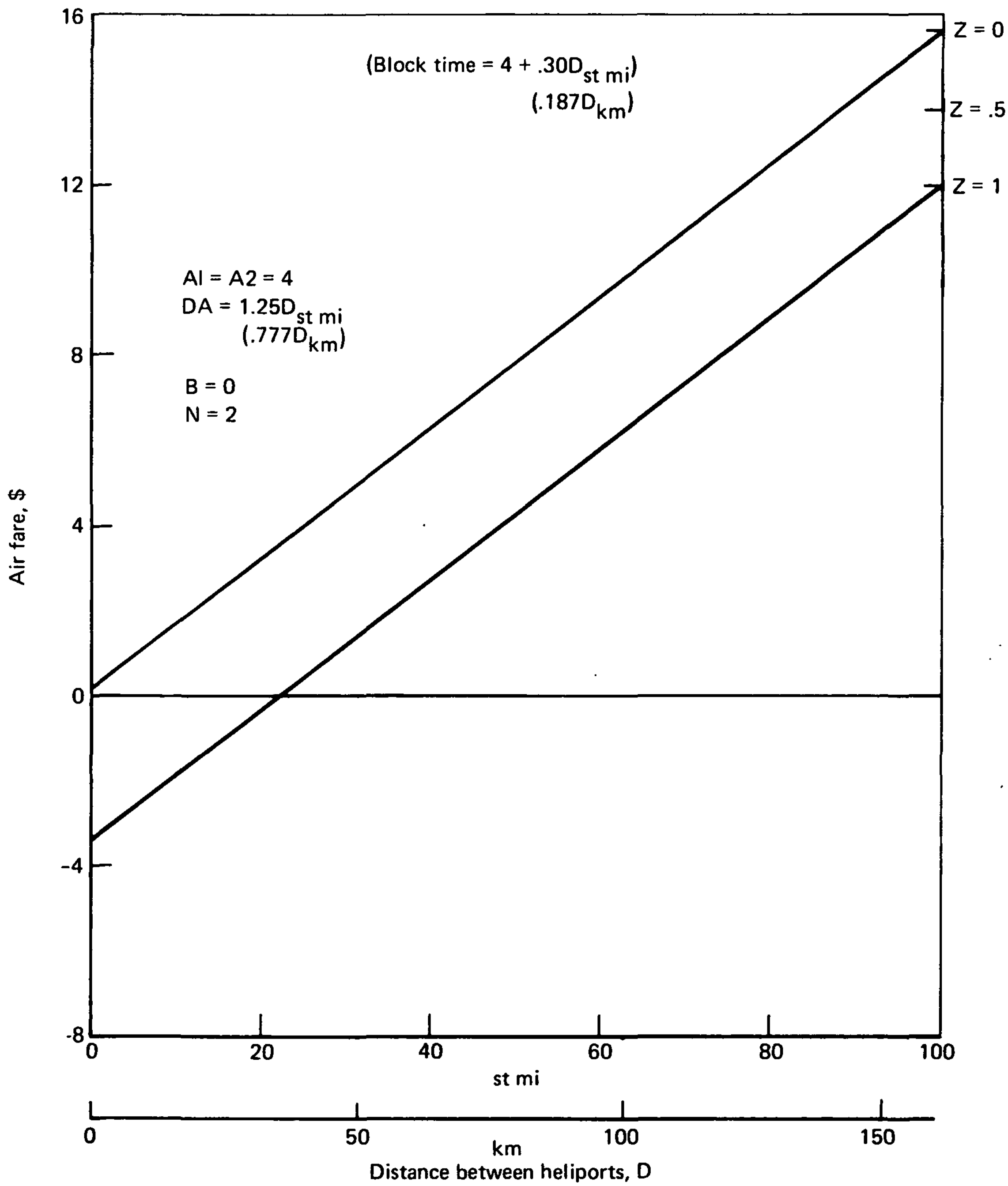


FIGURE 11-14.—1975 HELICOPTER AIR FARE VS DISTANCE

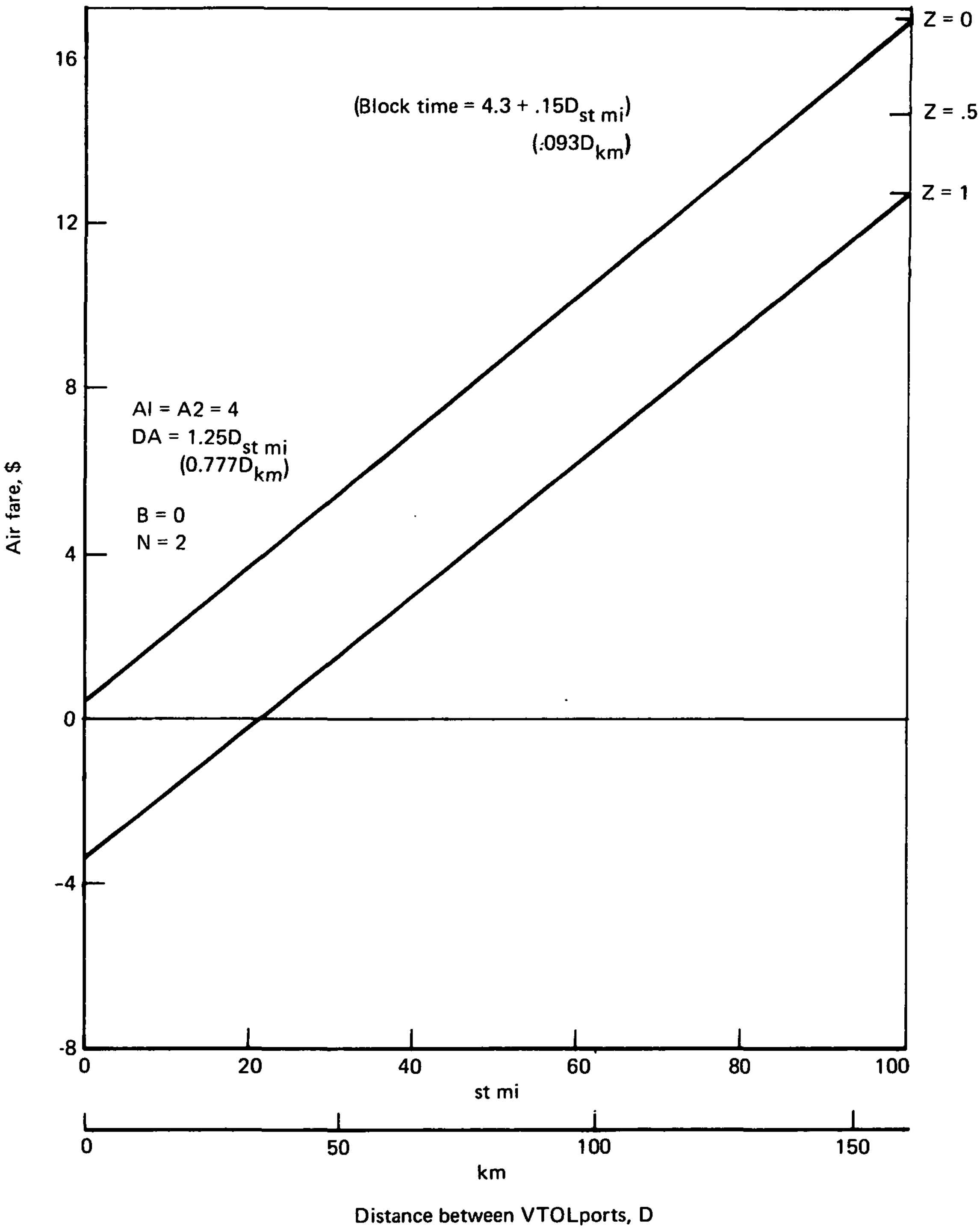


FIGURE 11-15.–1985 TILT-ROTOR VTOL FARE VS DISTANCE

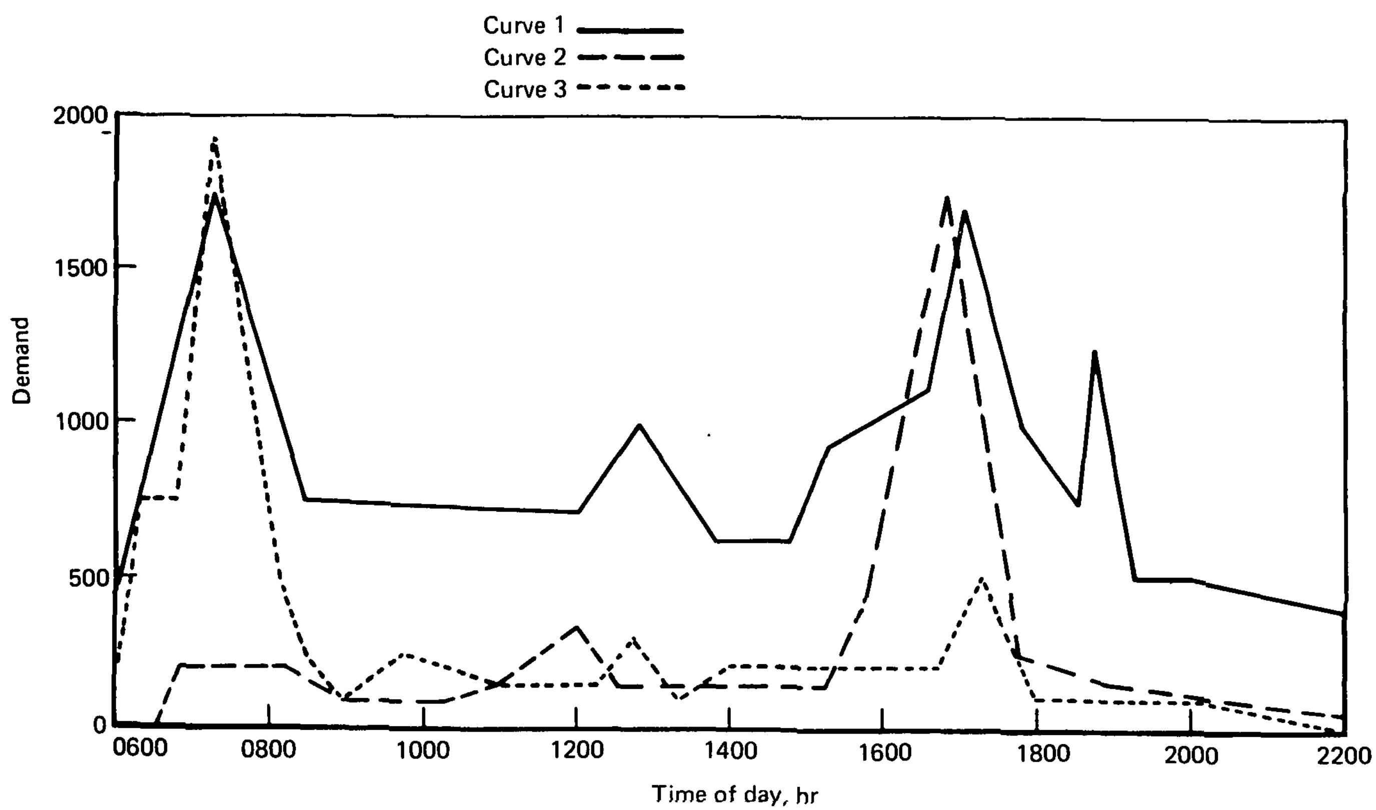


FIGURE 11-16.—TIME-OF-DAY DEMAND

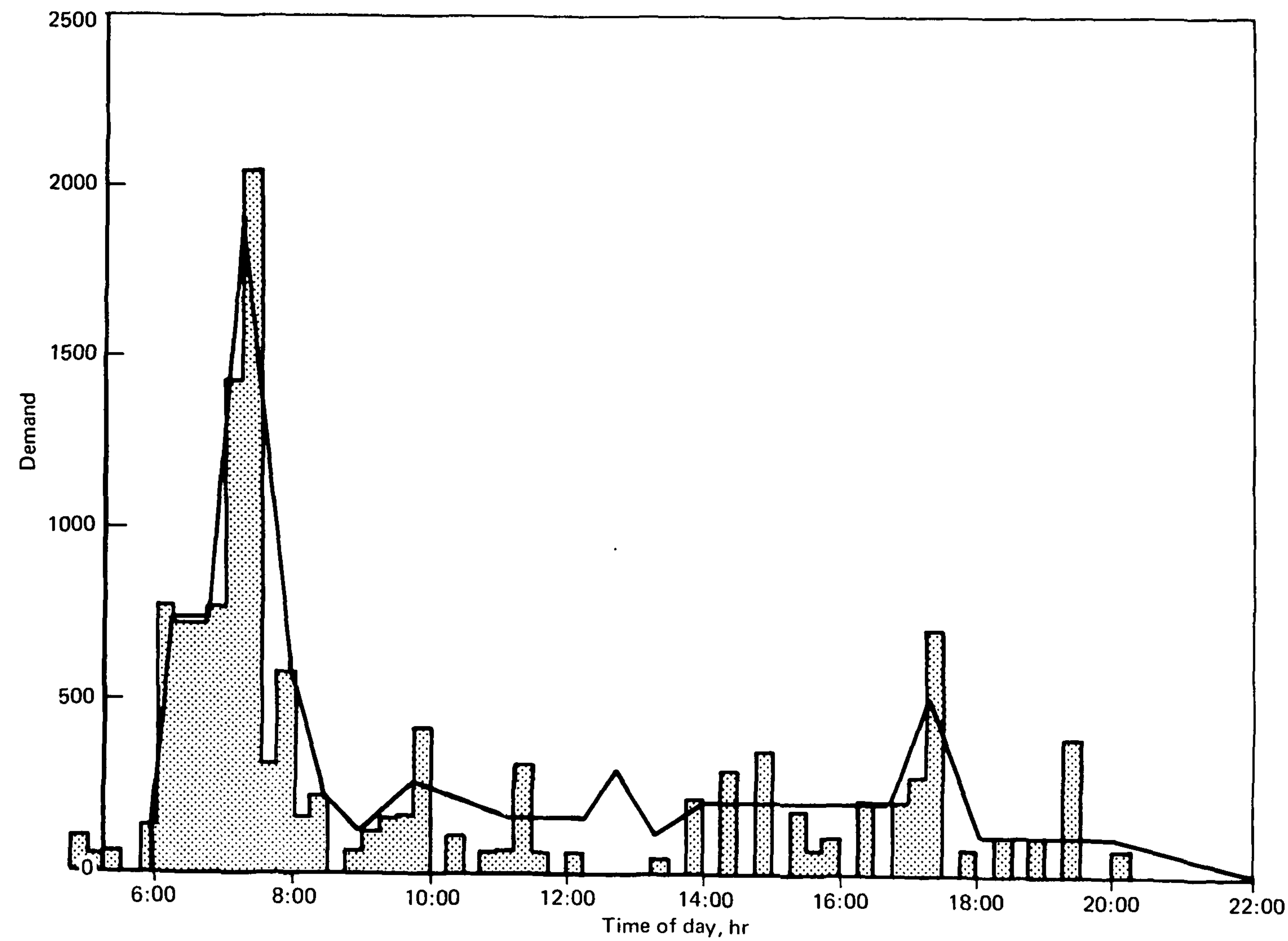


FIGURE 11-17.—TIME-OF-DAY DEMAND DISTRIBUTION FROM STOLPORT 6 TO 1

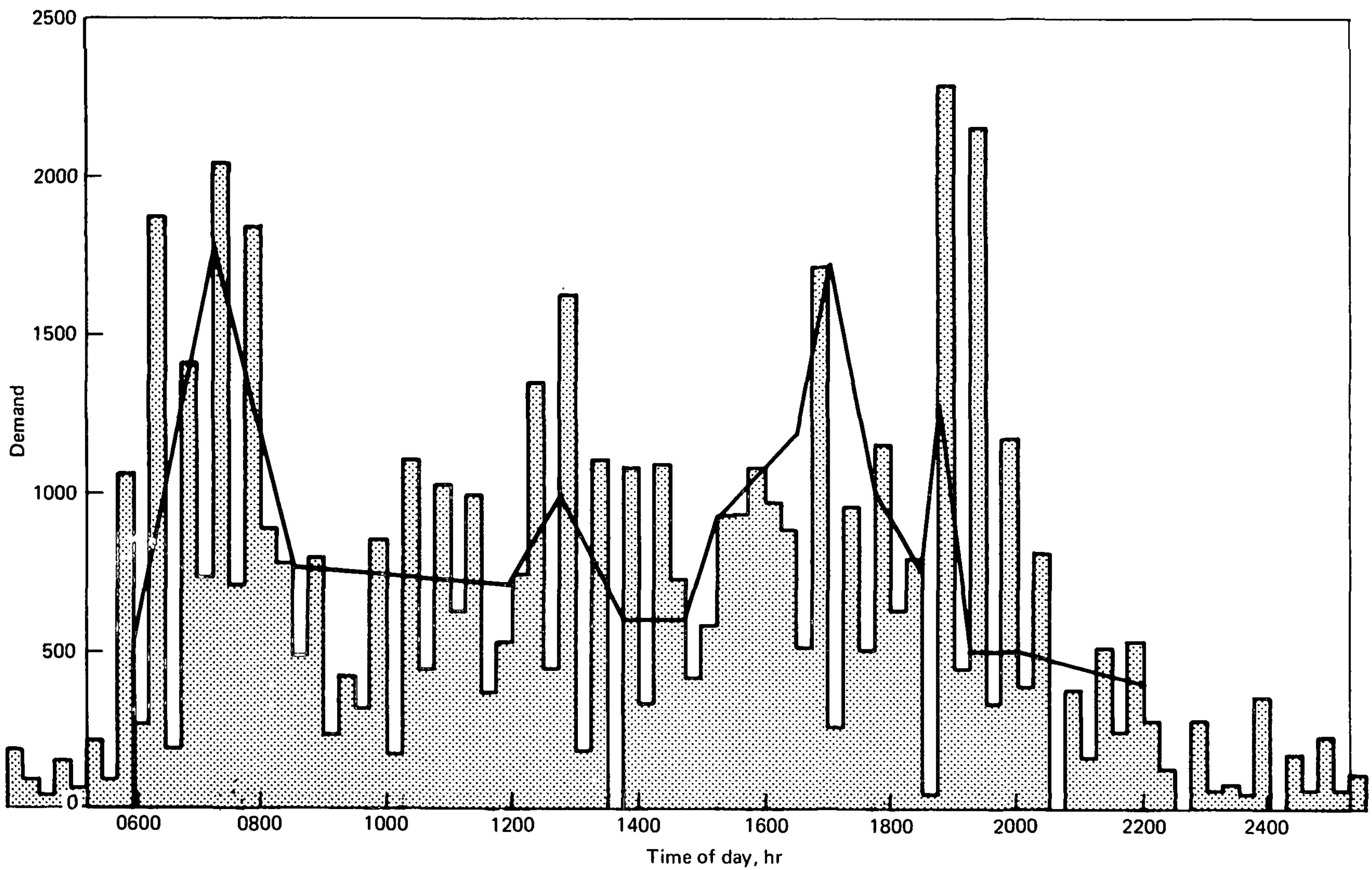


FIGURE 11-18.—TIME-OF-DAY DEMAND DISTRIBUTION FROM STOLPORT 14 TO 15

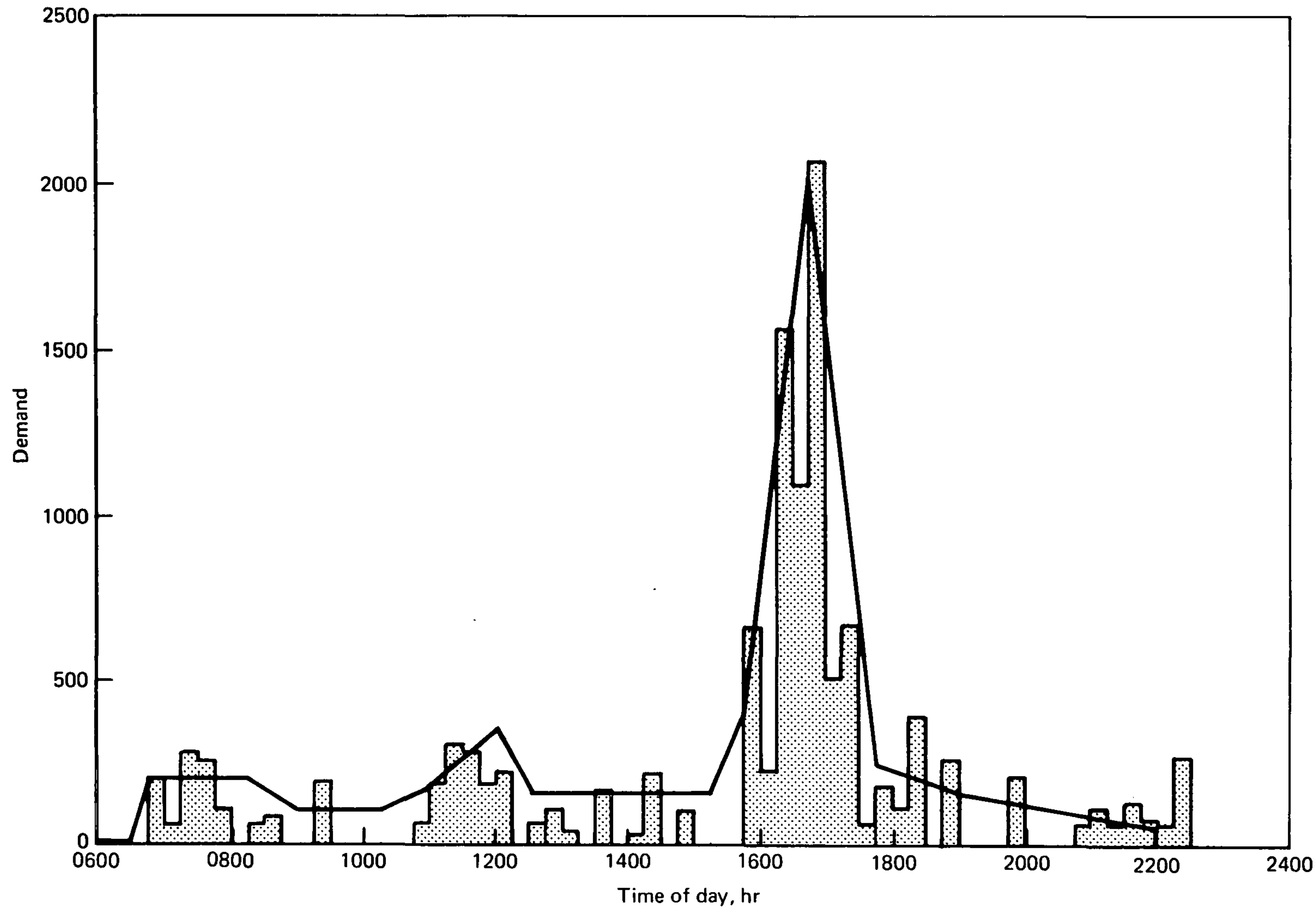


FIGURE 11-19.—TIME-OF-DAY DEMAND DISTRIBUTION FROM STOLPORT 1 TO 15

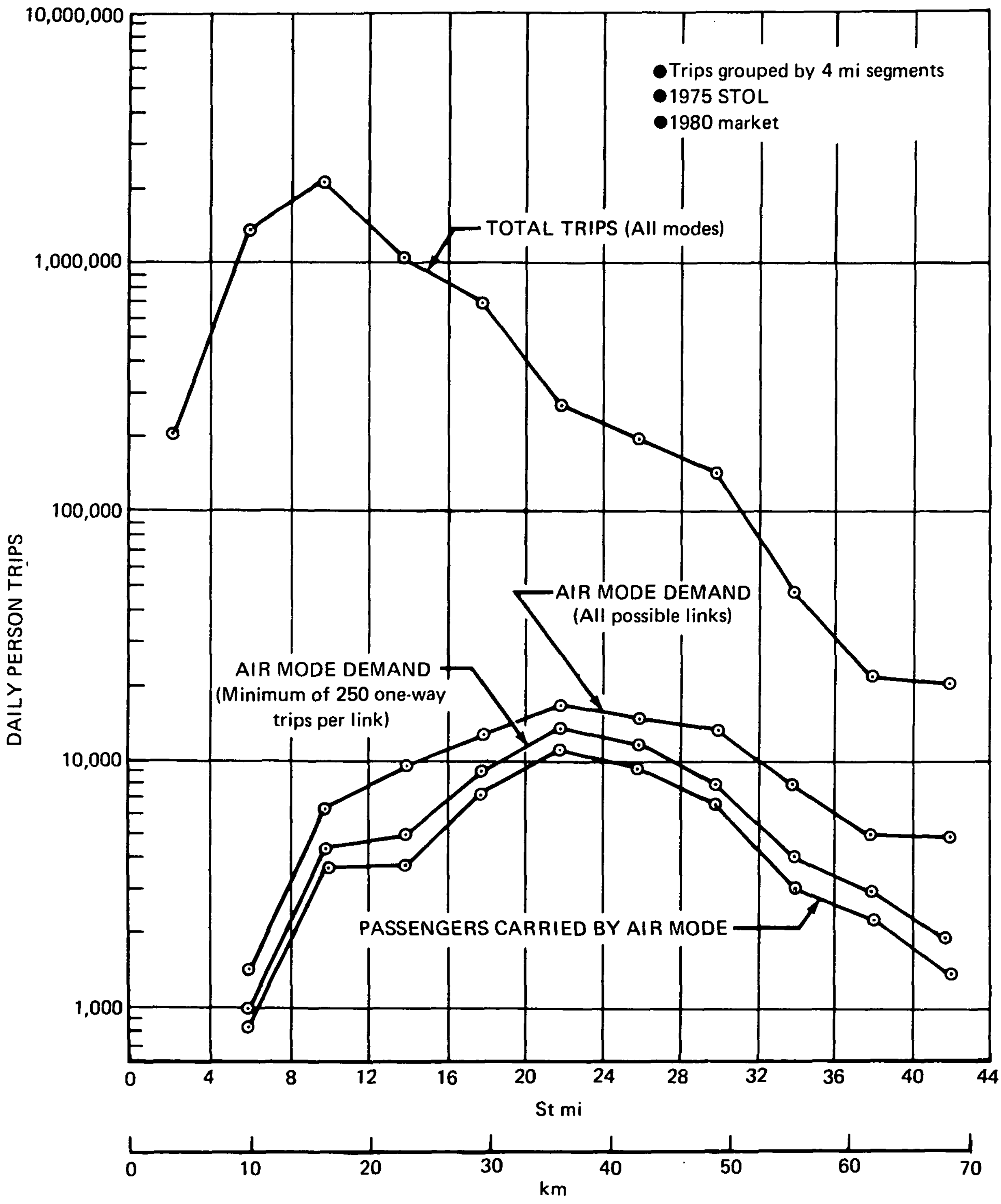


FIGURE 11-20.–EFFECT OF MODAL SPLIT AND SCHEDULING ON TOTAL DAILY PASSENGER DEMAND

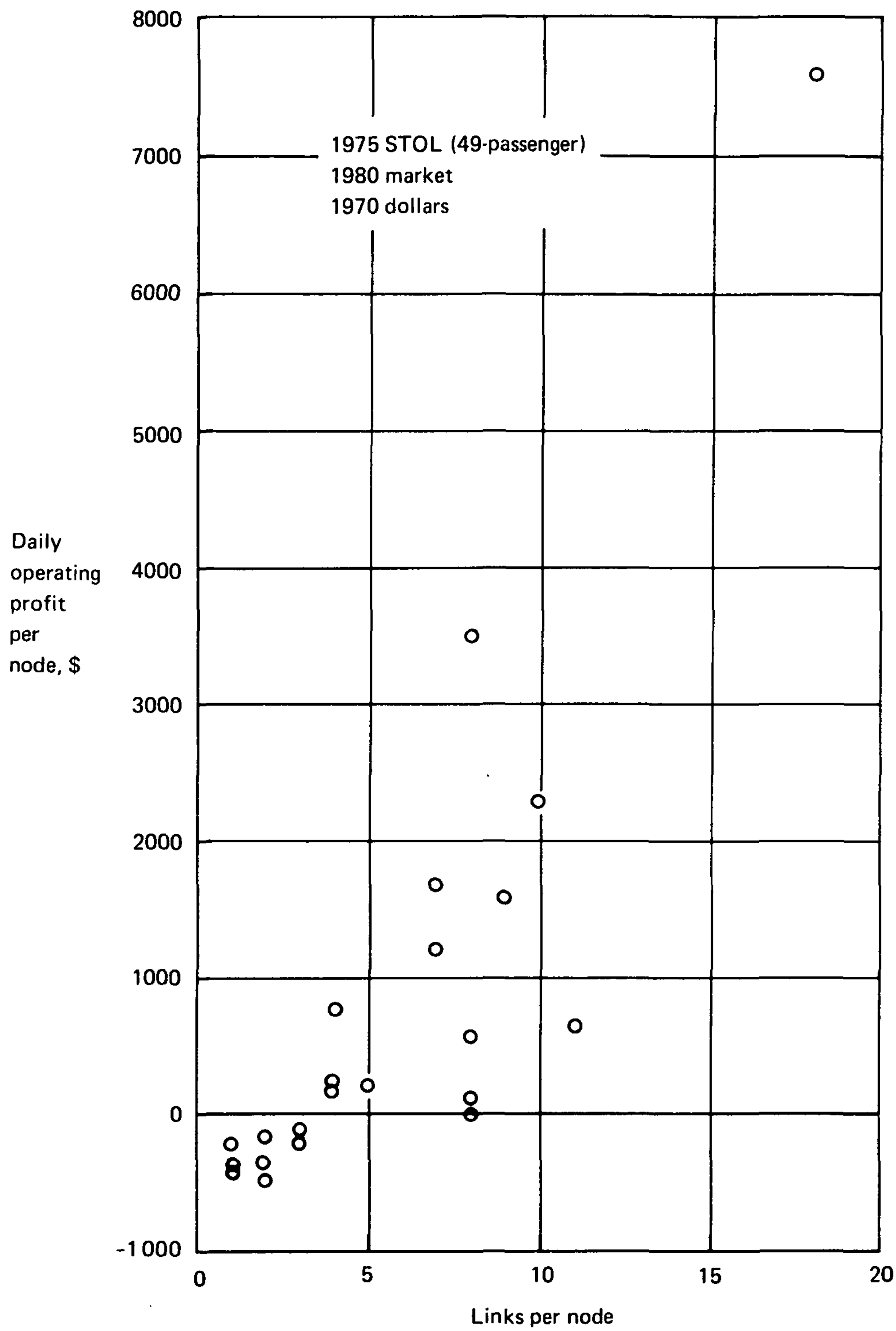


FIGURE 11-21.—EFFECT OF NUMBER OF LINKS PER NODE ON OPERATING PROFIT

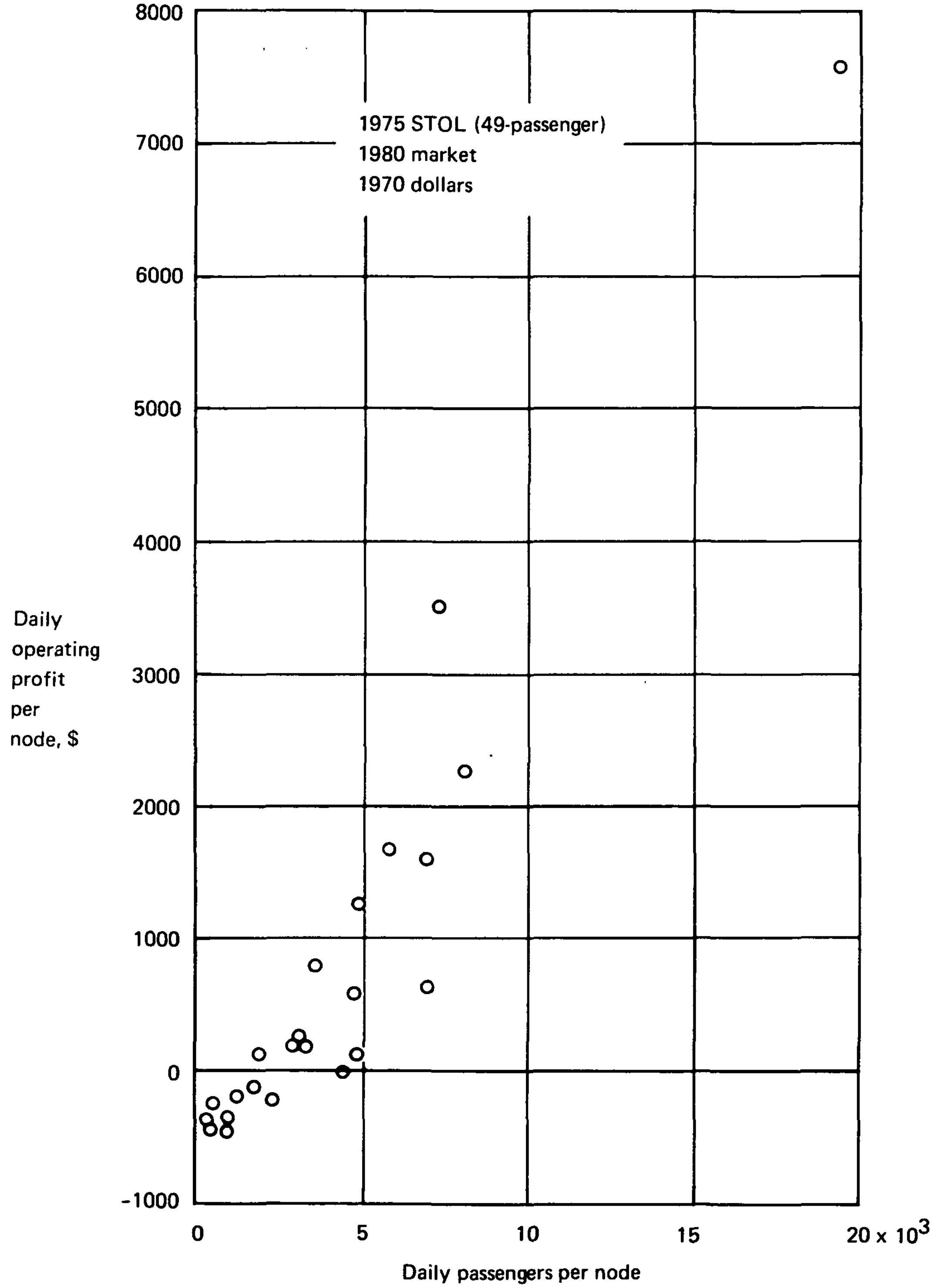


FIGURE 11-22.—EFFECT OF NUMBER OF PASSENGERS PER NODE ON OPERATING PROFIT

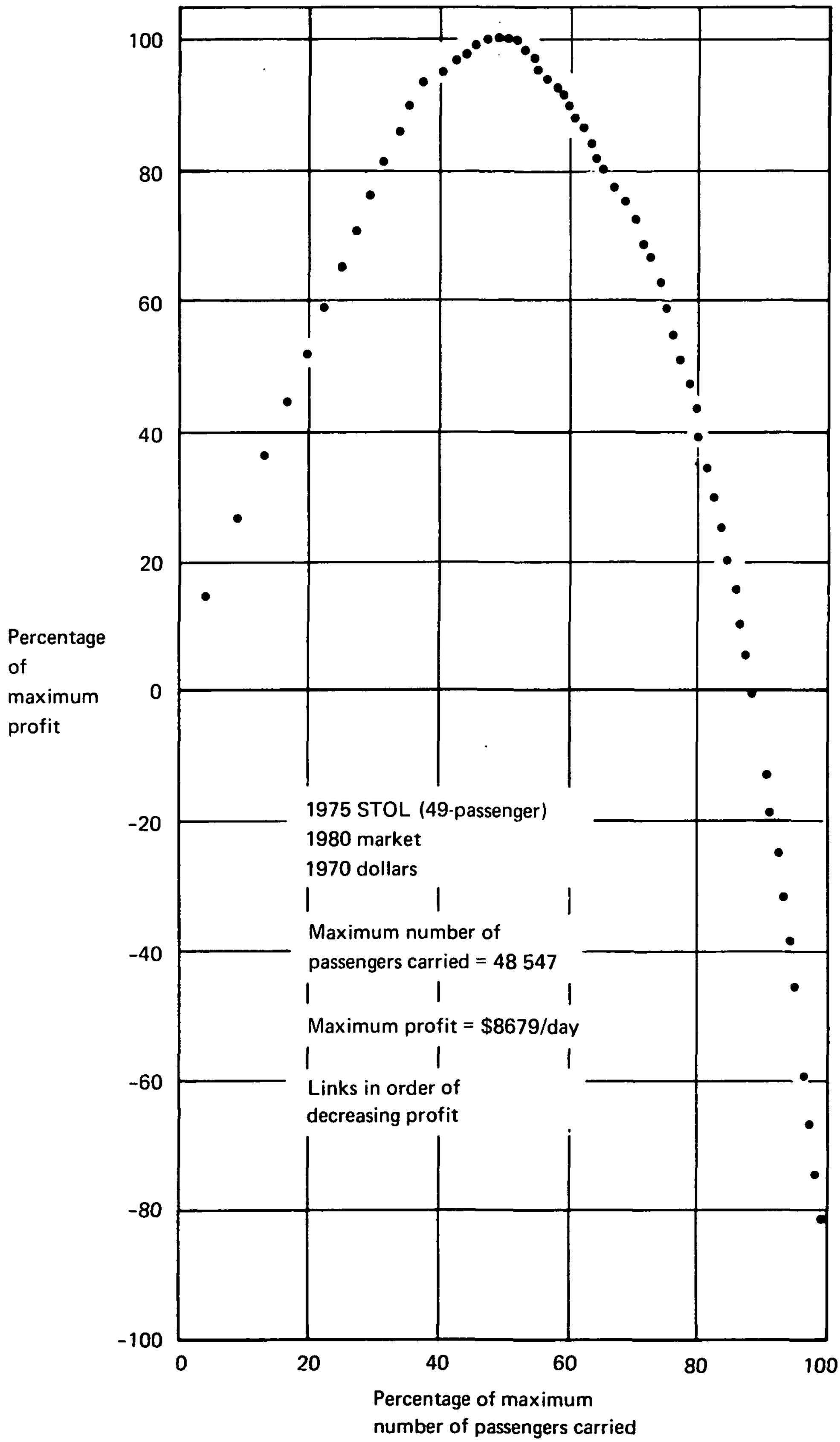


FIGURE 11-23.–EFFECT OF SELECTING LINKS ACCORDING TO PROFITABILITY ON PERCENT OF PASSENGERS CARRIED

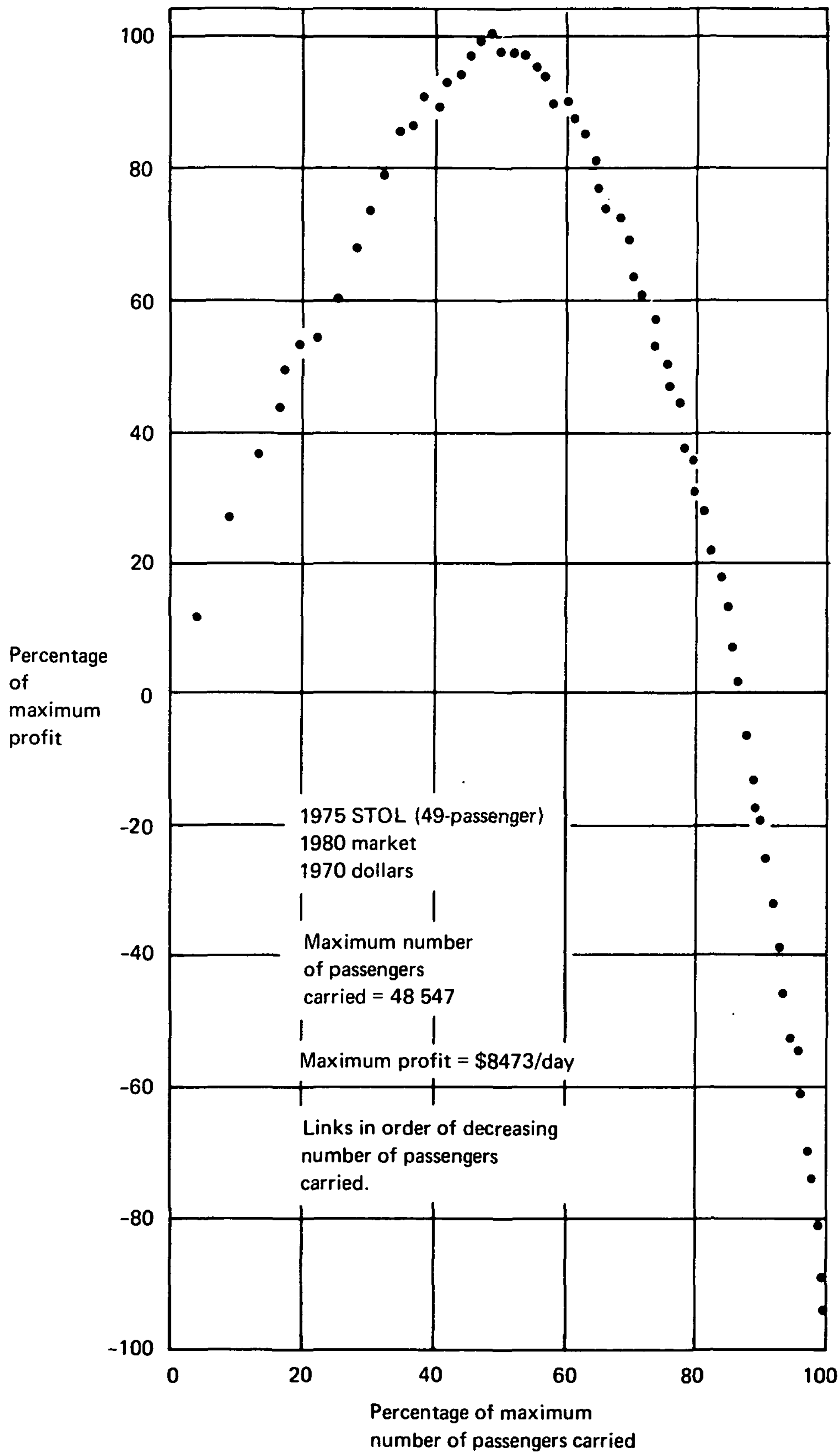


FIGURE 11-24.—EFFECT OF SELECTING LINKS ACCORDING TO NUMBER OF PASSENGERS CARRIED ON SYSTEM OPERATING PROFIT

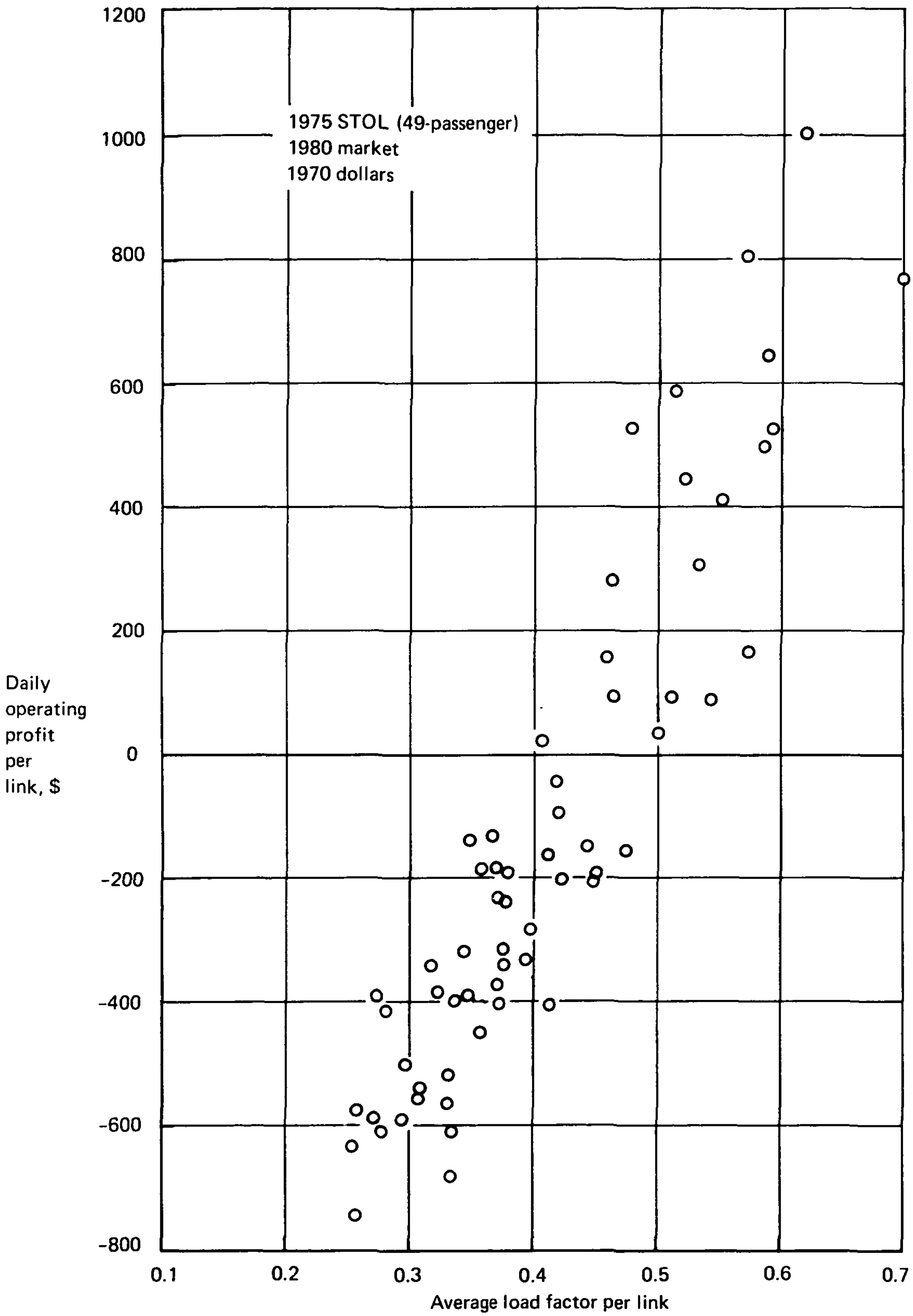


FIGURE 11-25.—EFFECT OF AVERAGE LOAD FACTOR PER LINK ON OPERATING PROFIT PER LINK

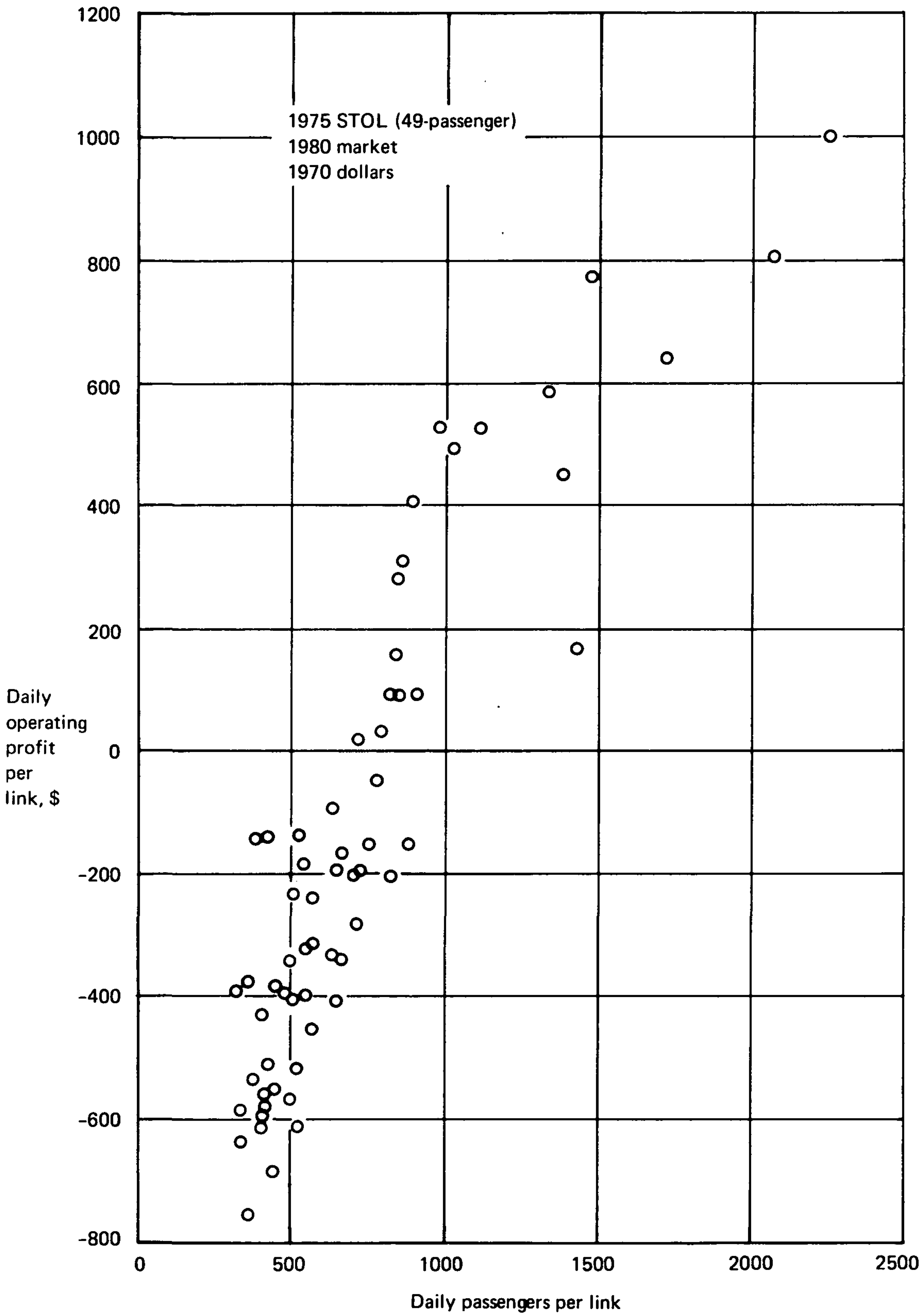


FIGURE 11-26.—EFFECT OF NUMBER OF PASSENGERS PER LINK ON OPERATING PROFIT PER LINK

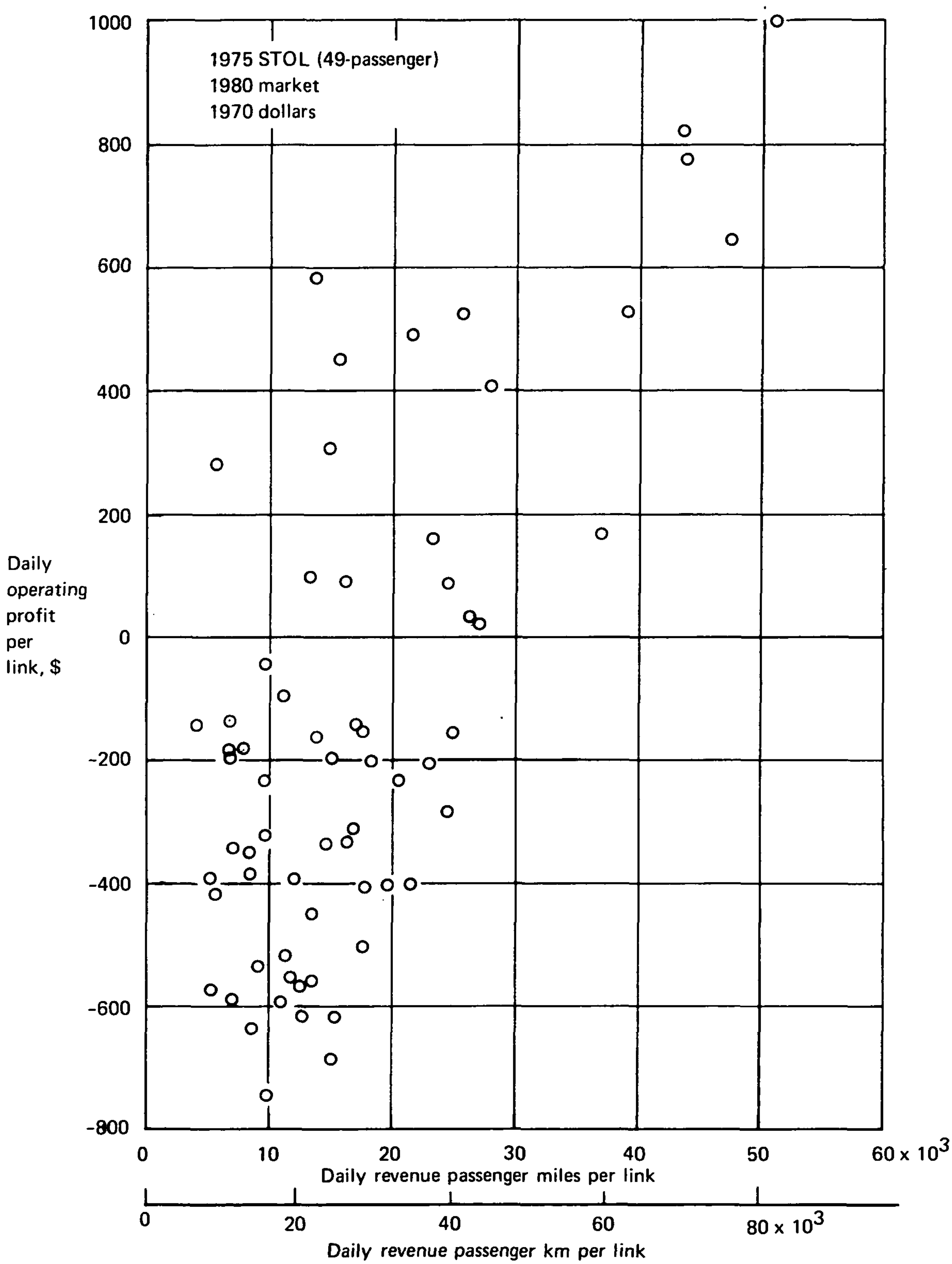


FIGURE 11-27.–CORRELATION BETWEEN REVENUE PASSENGER MILES PER LINK AND OPERATING PROFIT PER LINK

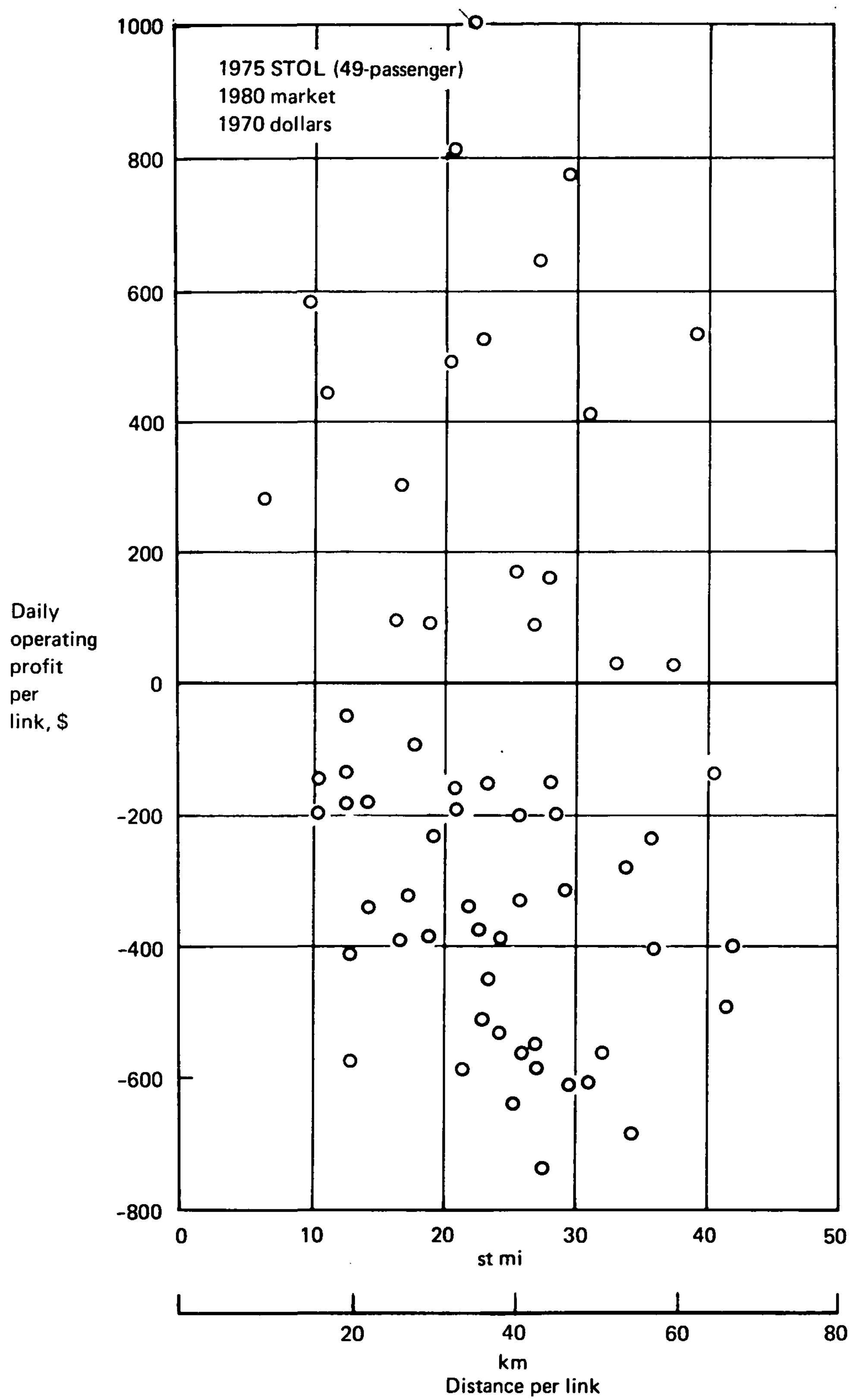


FIGURE 11-28.—CORRELATION BETWEEN DISTANCE PER LINK AND OPERATING PROFIT PER LINK

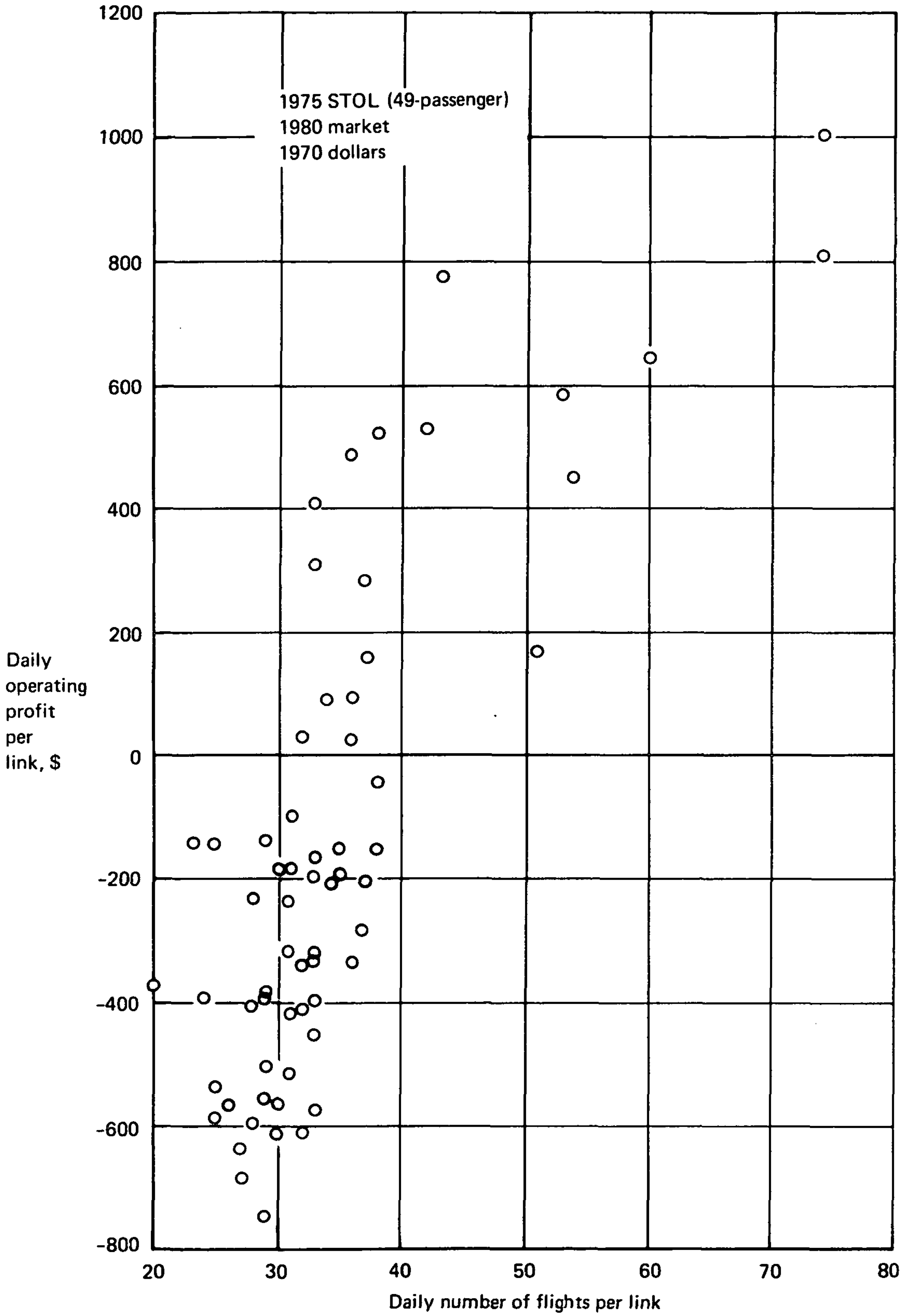


FIGURE 11-29.–EFFECT OF NUMBER OF FLIGHTS PER LINK ON OPERATING PROFIT PER LINK.

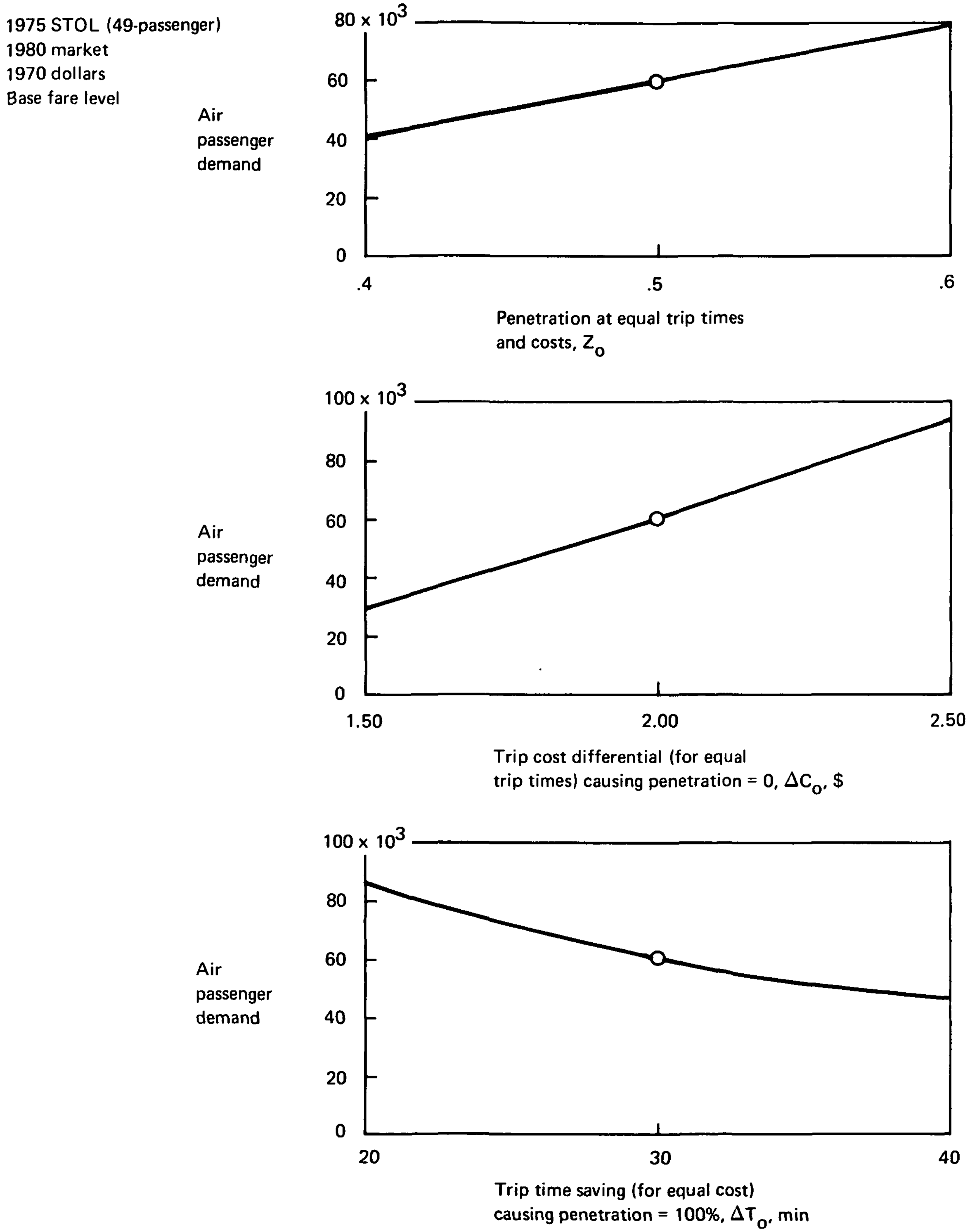


FIGURE 11-30.—MODAL-SPLIT INTERCEPT SENSITIVITIES

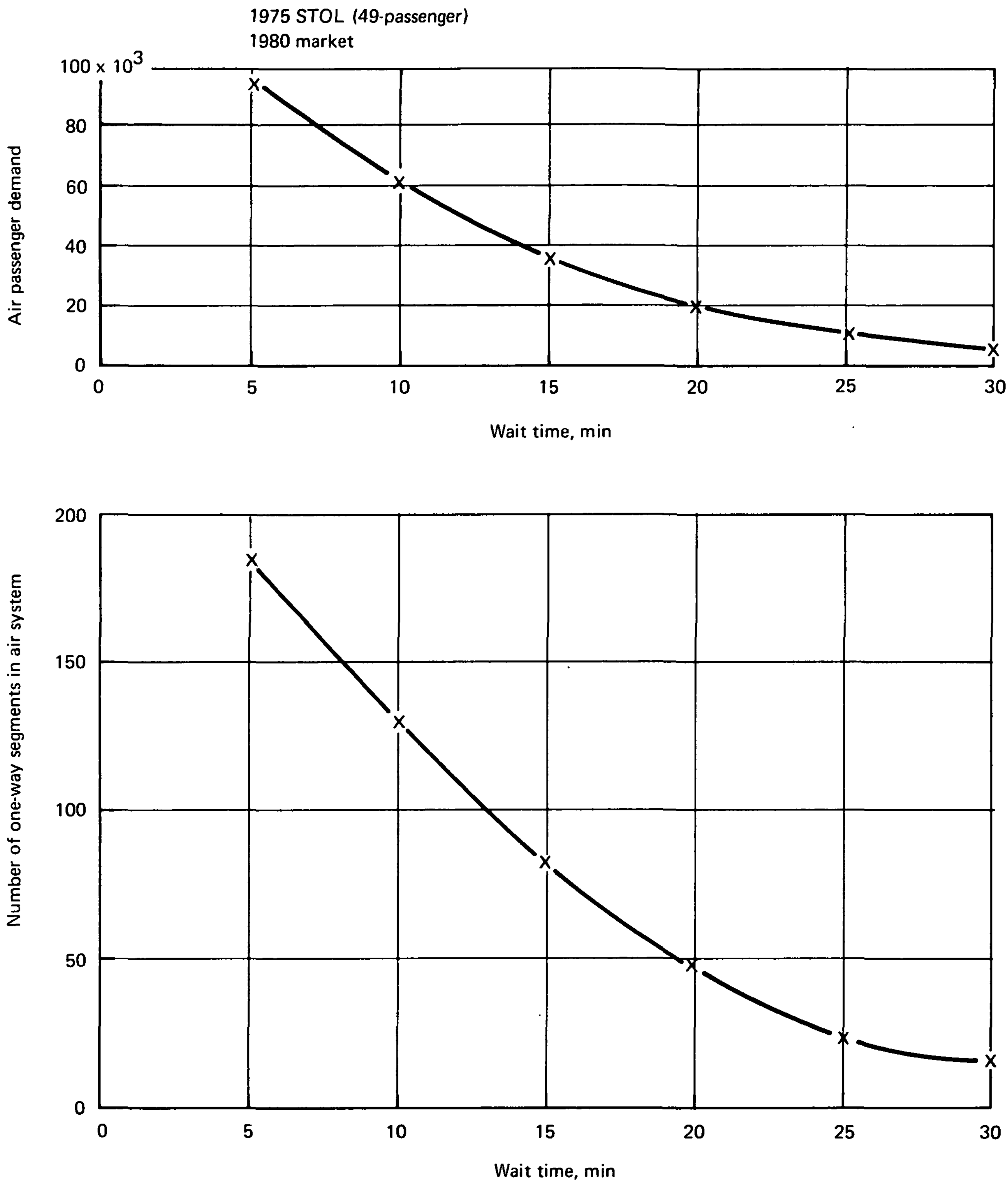


FIGURE 11-31.—EFFECT OF WAIT TIME ON AIR DEMAND

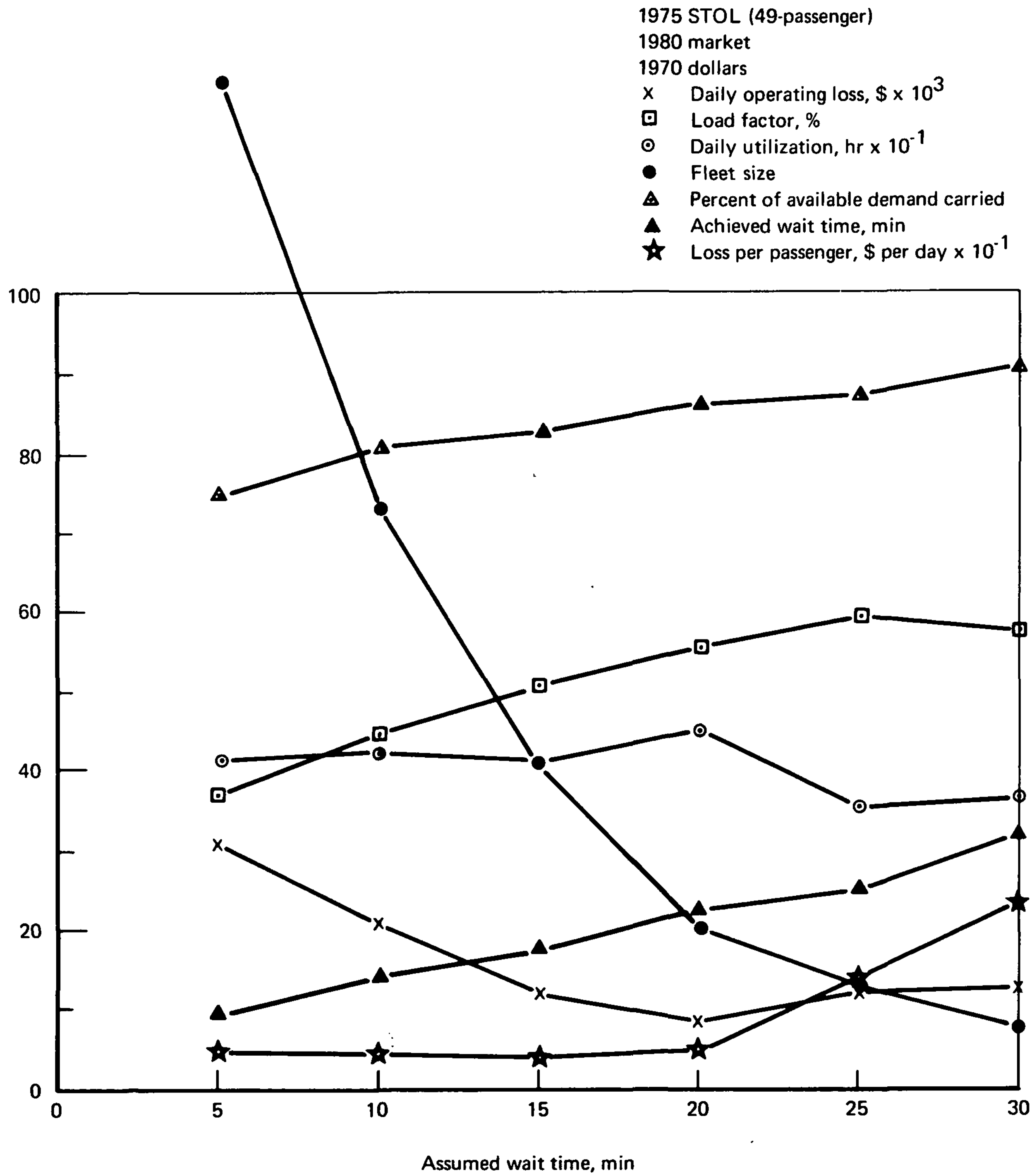


FIGURE 11-32.–OPERATIONAL EFFECTS OF WAIT TIME

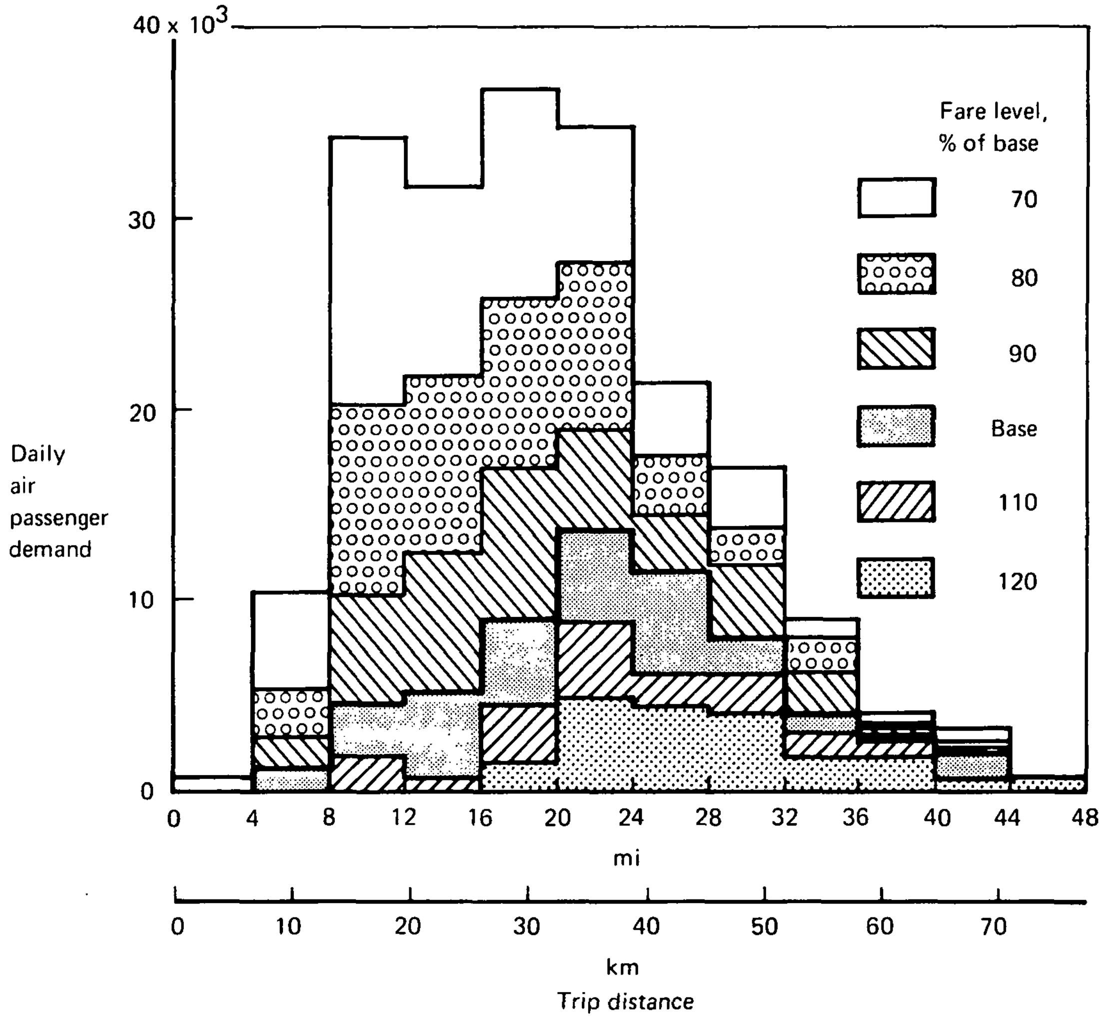


FIGURE 11-33.—TRAVEL DEMAND SENSITIVITY TO FARE 1975 STOL, 1980 MARKET

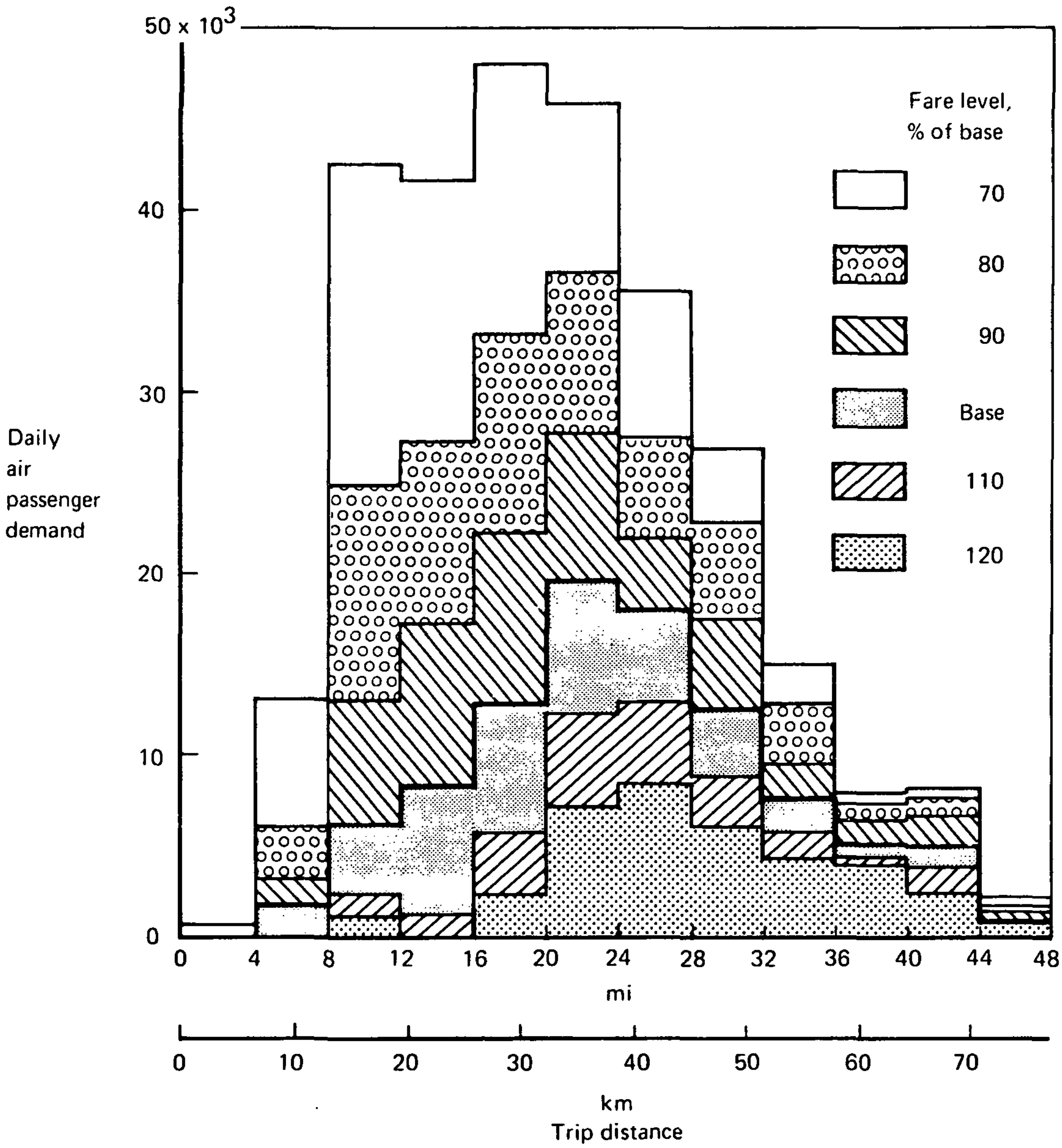
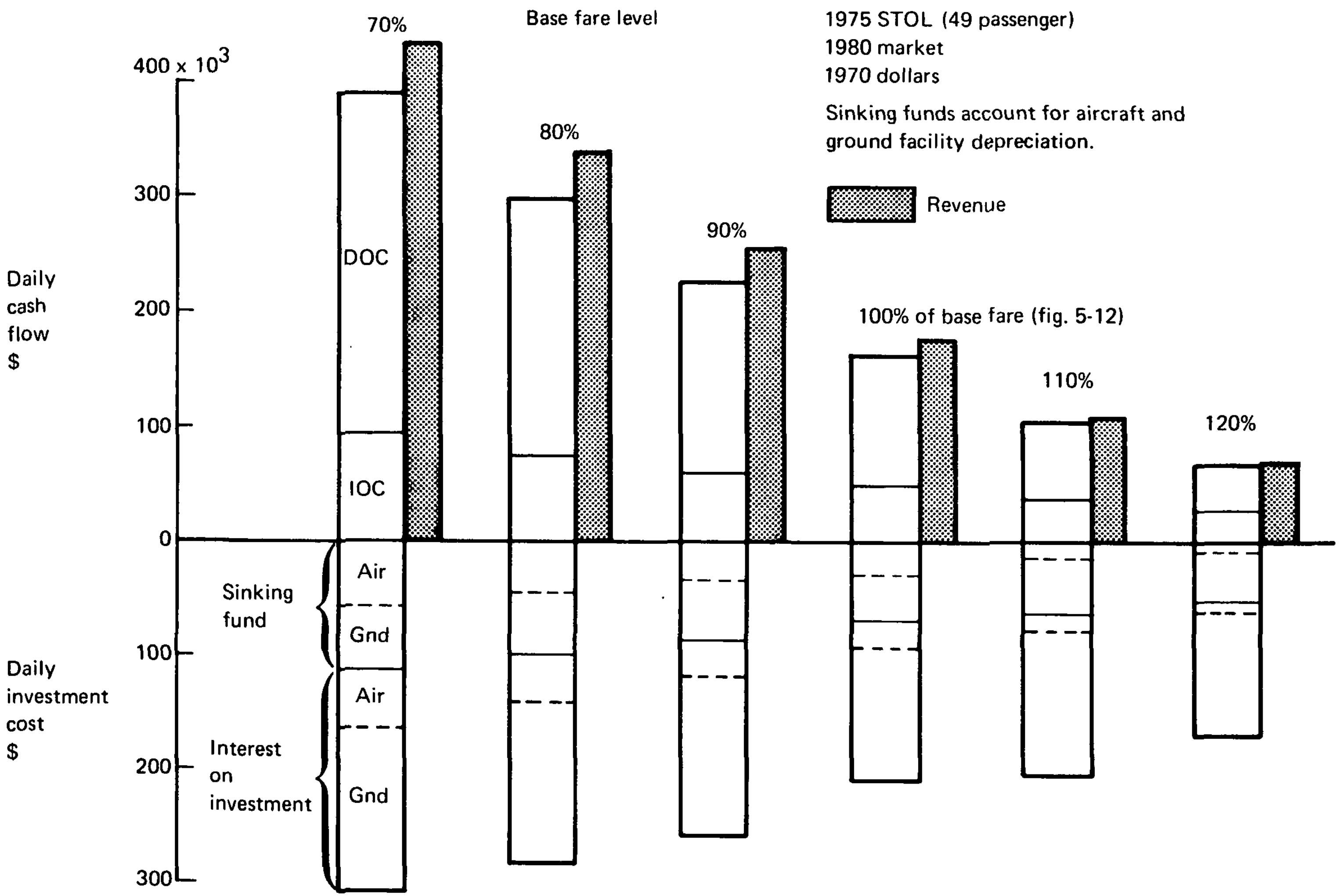


FIGURE 11-34.—TRAVEL DEMAND SENSITIVITY TO FARE 1985 STOL, 1990 MARKET



Daily passengers	173 648	119 243	78 922	48 551	26 582	14 501
Average load factor	0.57	0.53	0.49	0.45	0.44	0.41
Loss per passenger	$1.53	$2.04	$2.92	$4.05	$7.66	$11.55

FIGURE 11-35.—FARE LEVEL SENSITIVITY

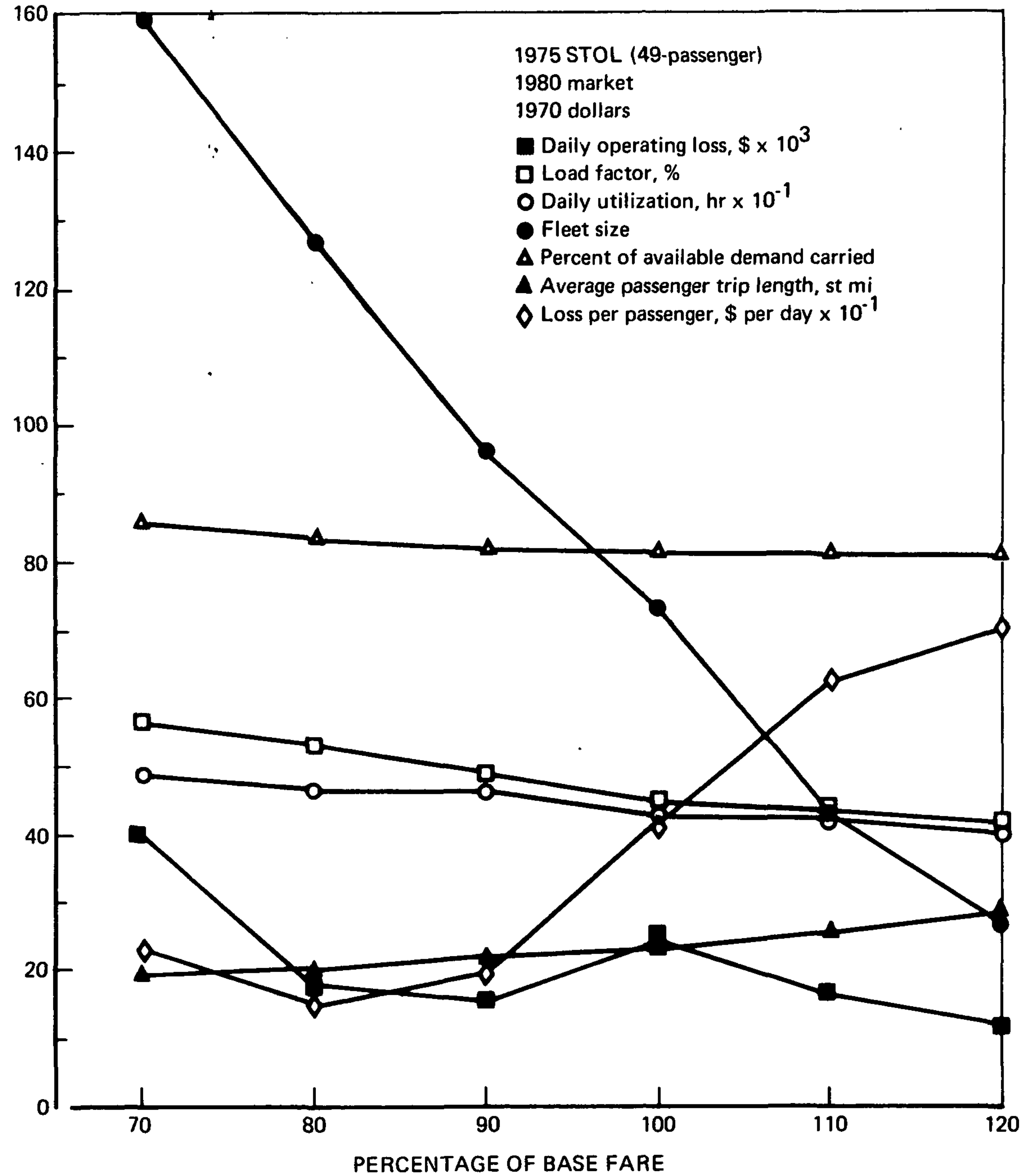


FIGURE 11-36.—OPERATIONAL EFFECTS OF FARE VARIATIONS

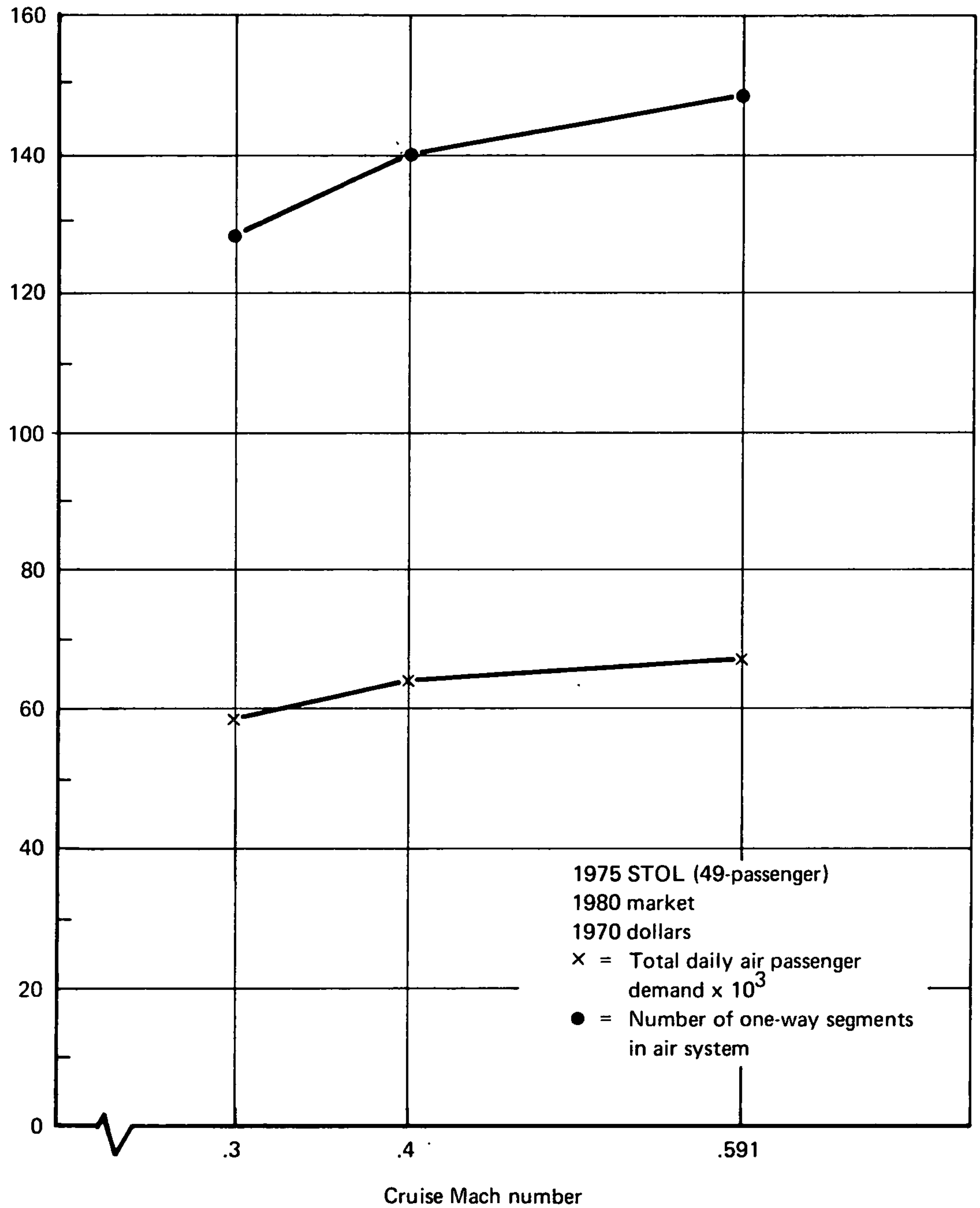


FIGURE 11-37.–DEMAND EFFECTS OF BLOCK SPEED

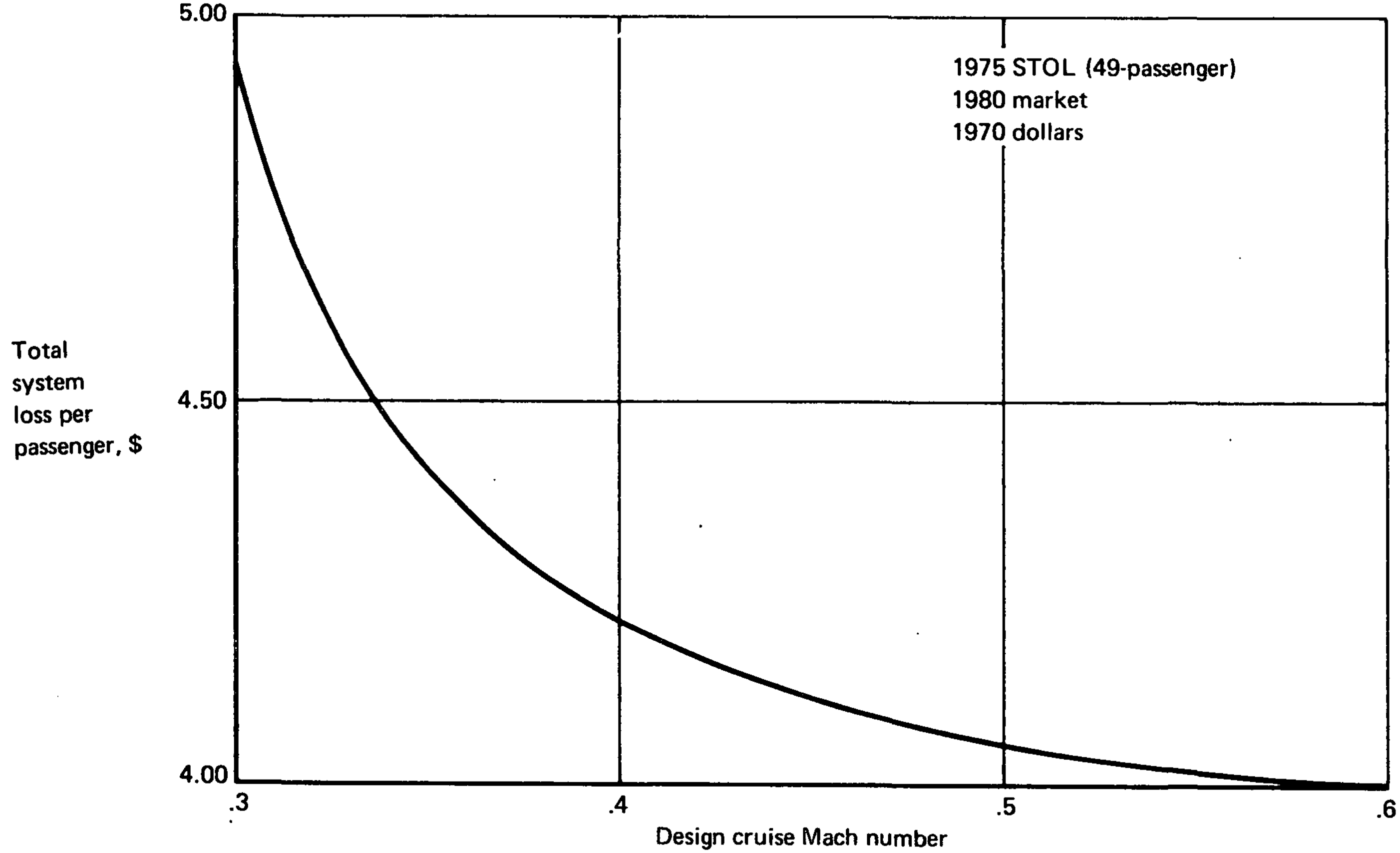


FIGURE 11-38.—DESIGN CRUISE MACH NUMBER SENSITIVITY

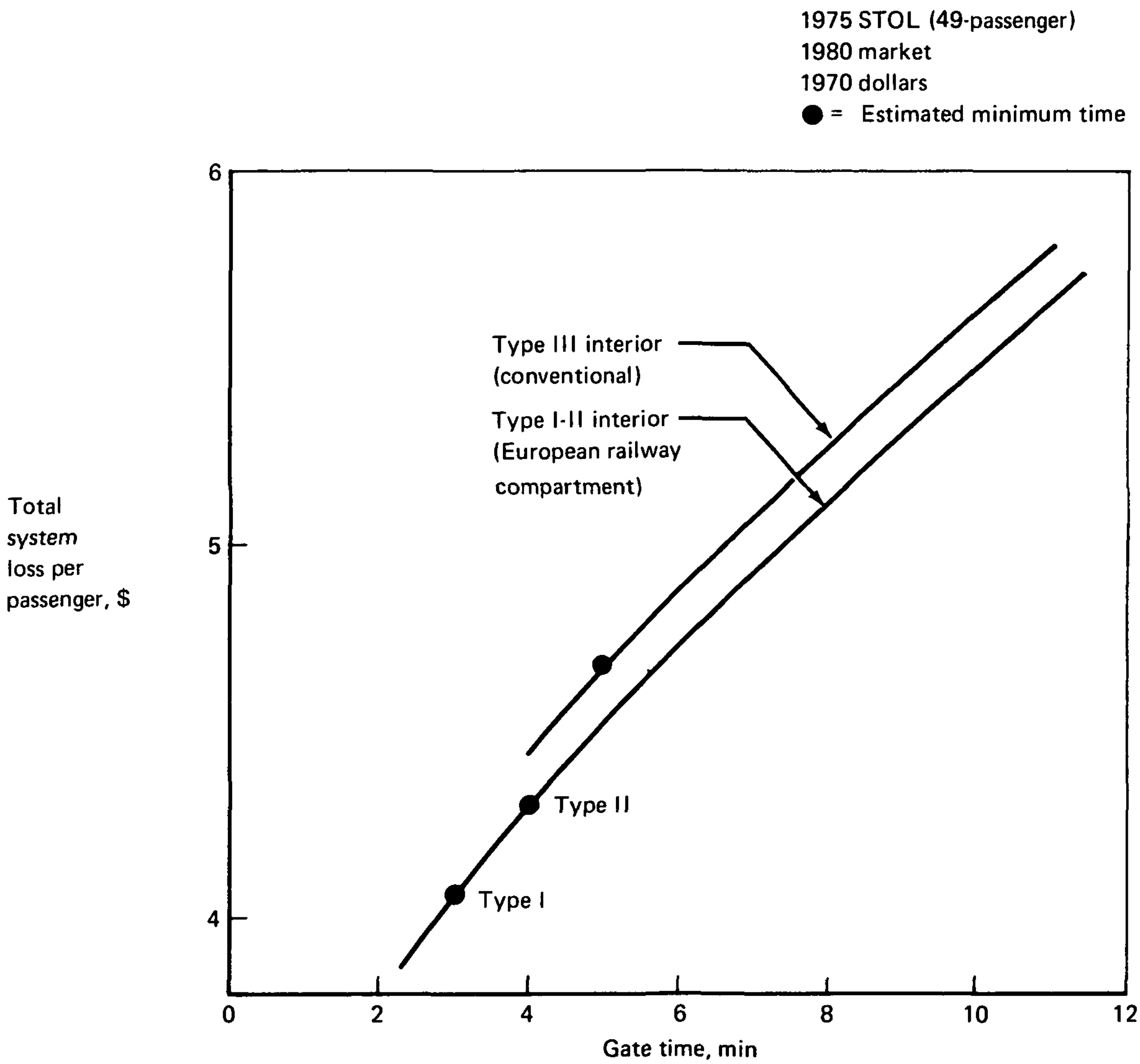


FIGURE 11-39.–GATE TIME SENSITIVITY

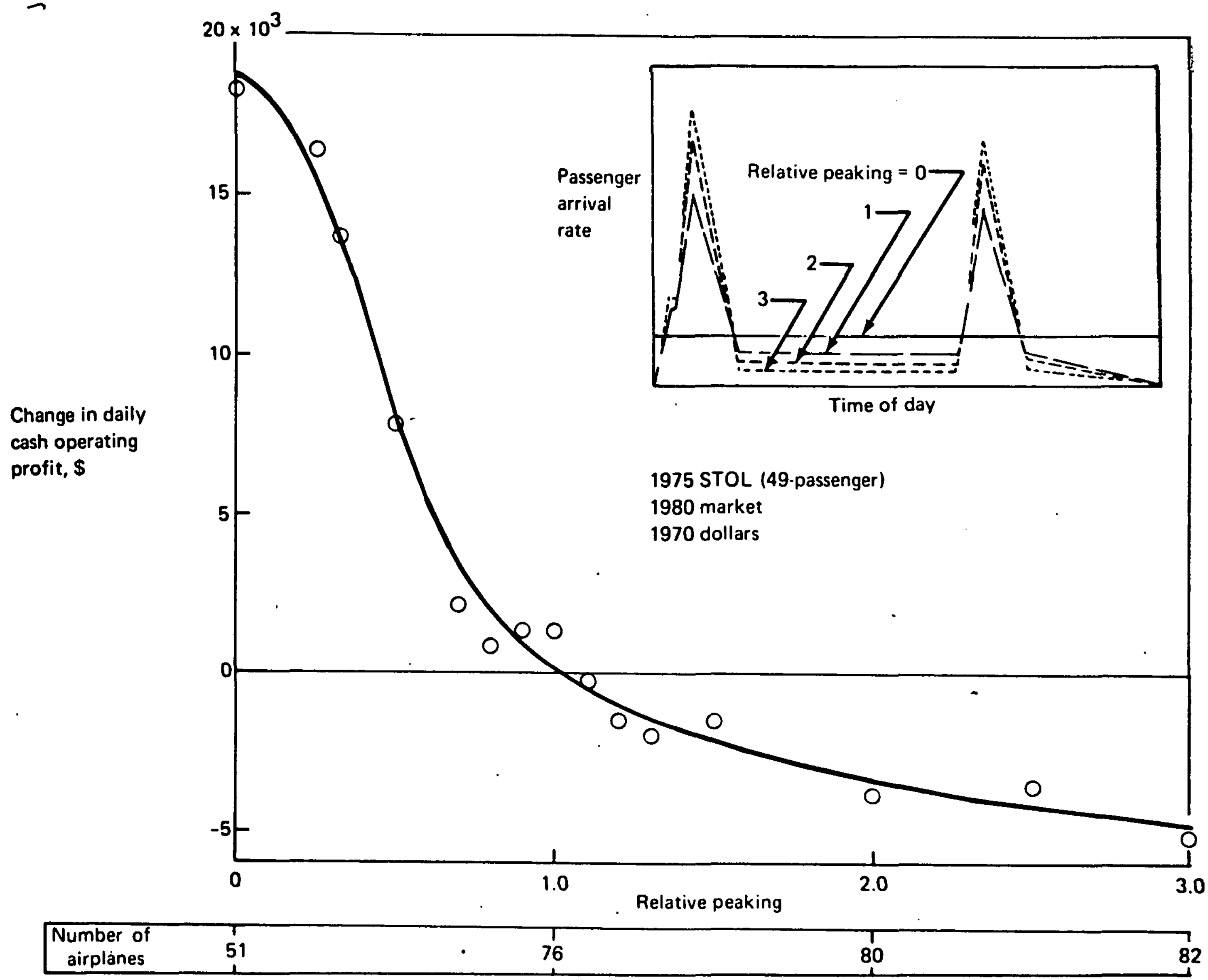
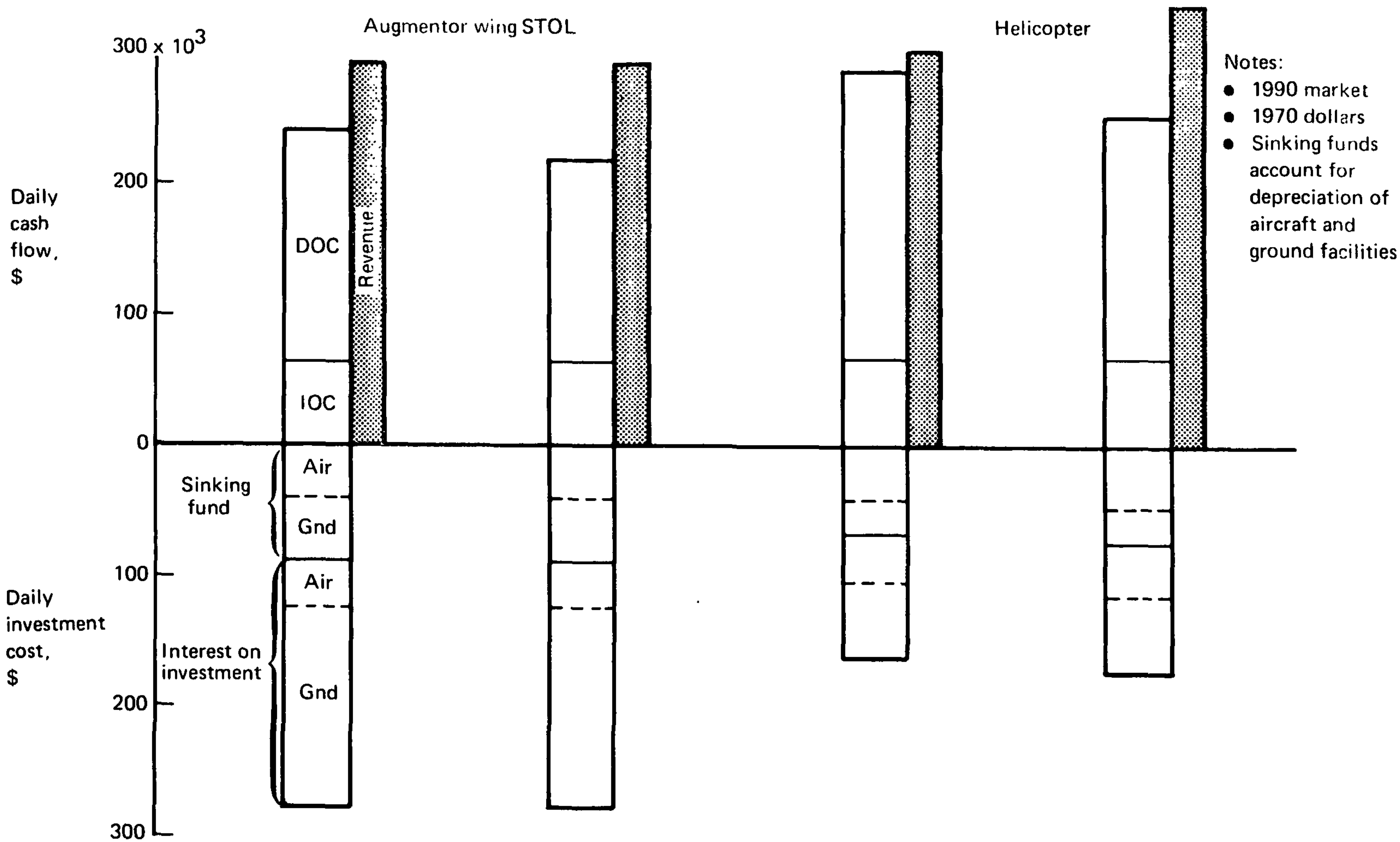
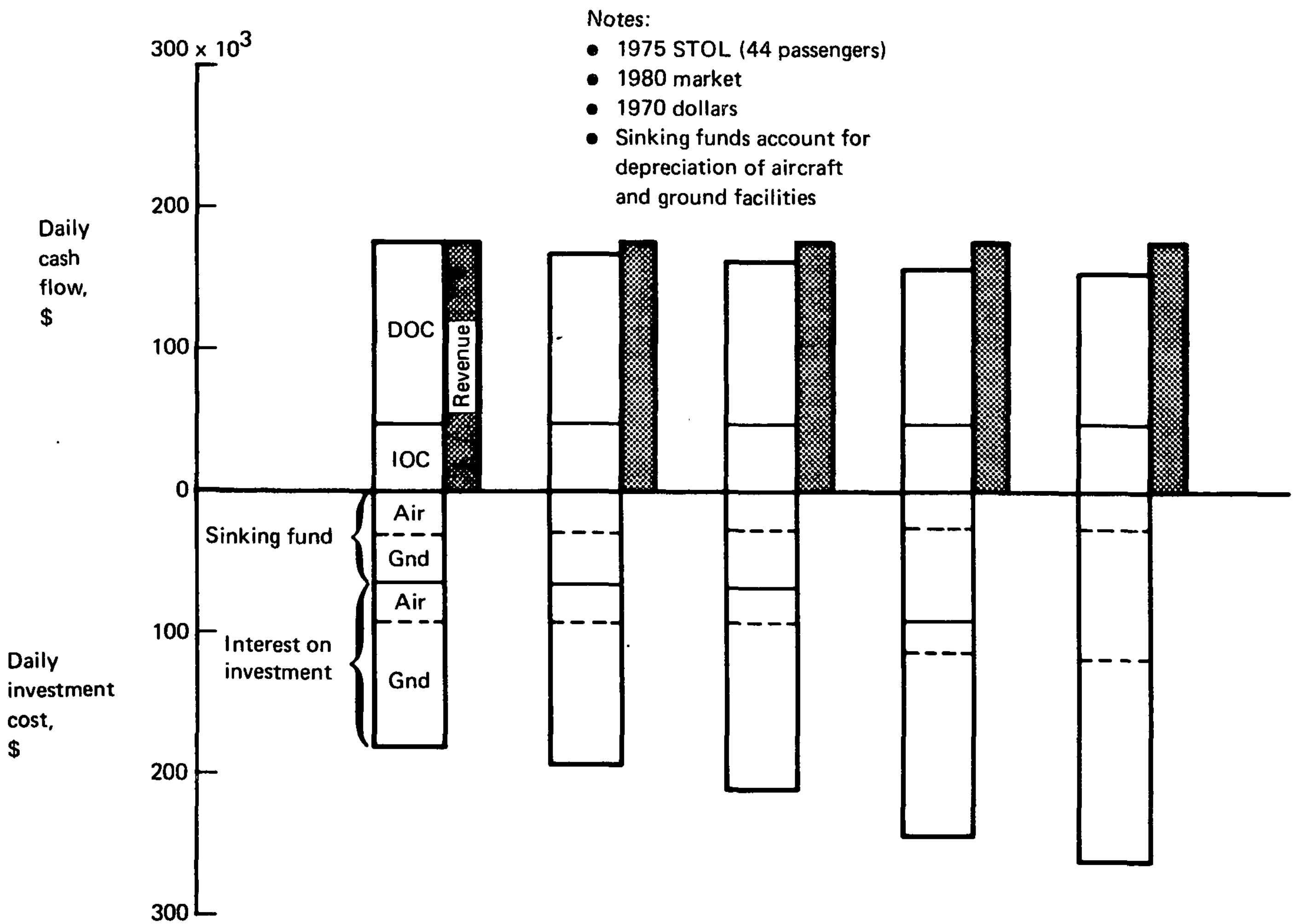


FIGURE 11-40.–PEAKING SENSITIVITY



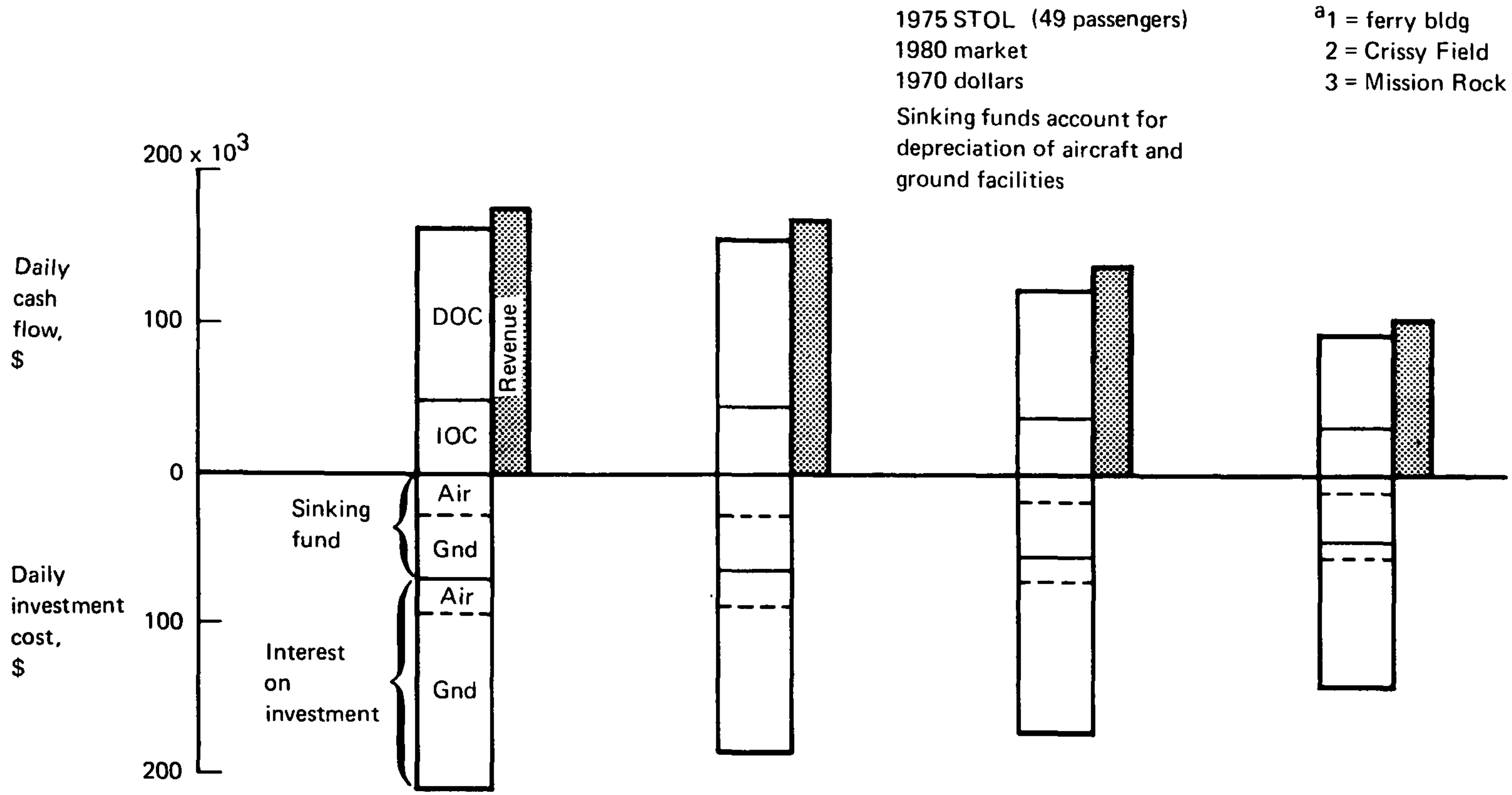
Vehicle	Augmentor wing STOL		Helicopter	
Passengers	49		50	
Loss per passenger	$2.86	$2.57	$1.77	$0.95
Technology	1975	1985	1975	1985

FIGURE 11-41.—TECHNOLOGY SENSITIVITY



Field length, ft	1000	1500	2000	2500	3000
m	305	457	610	762	915

FIGURE 11-42.—FIELD LENGTH SENSITIVITY



Ports eliminated[a]	None	1	1,3	1,2,3
Daily passengers	48 551	46 355	37 700	28 149
Loss per passenger	$4.05	$3.82	$4.19	$4.68

FIGURE 11-43.—SYSTEM SENSITIVITY TO ELIMINATION OF DOWNTOWN STOLPORTS

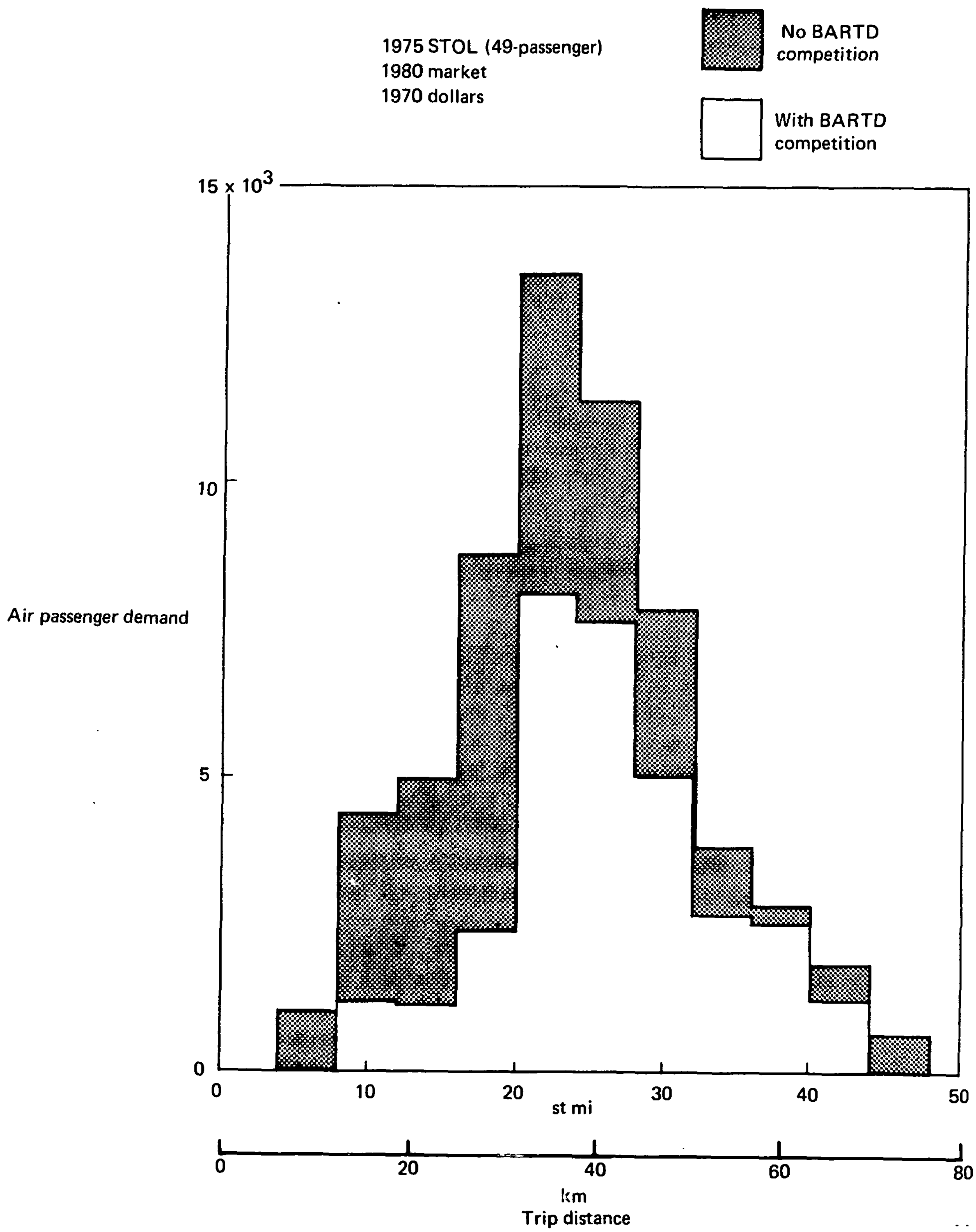


FIGURE 11-44.– EFFECT OF BARTD ON AIR DEMAND

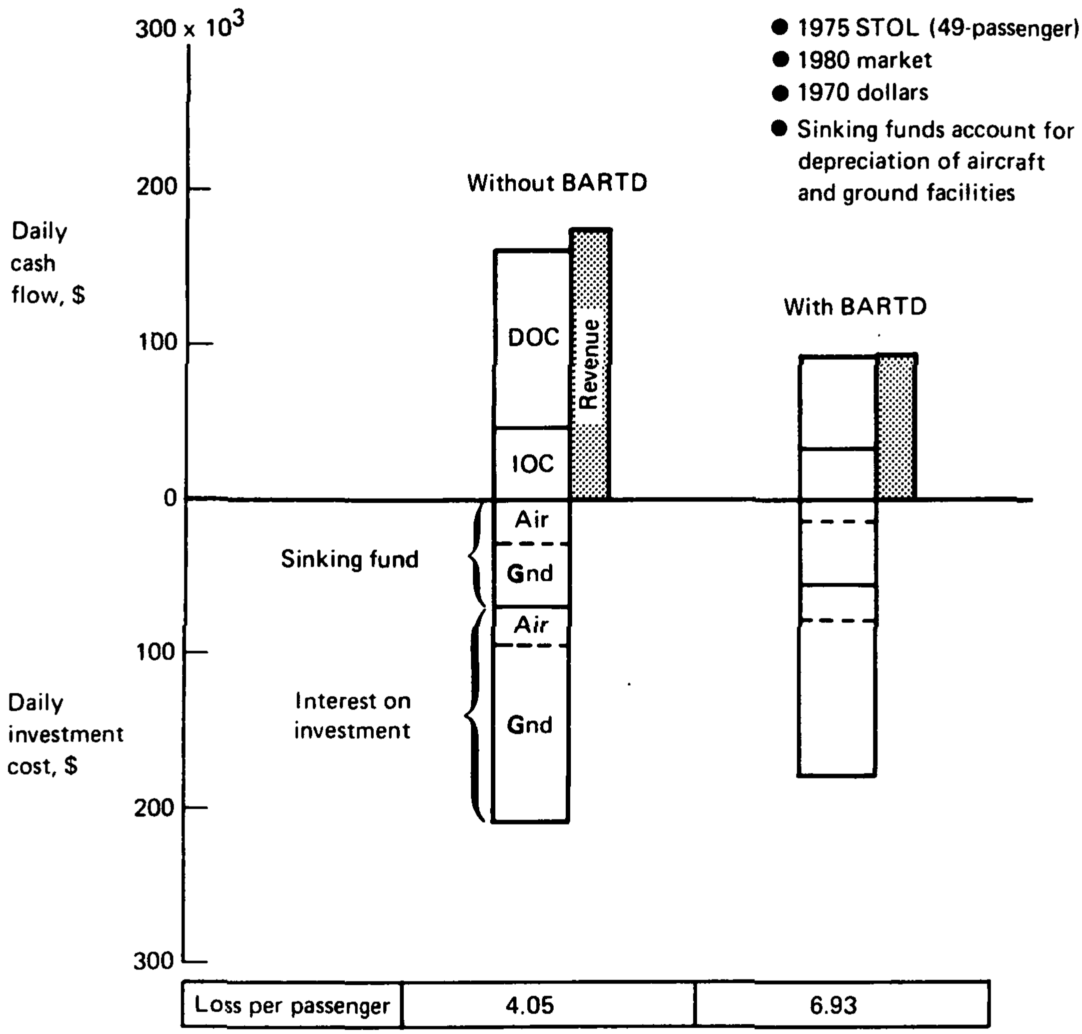
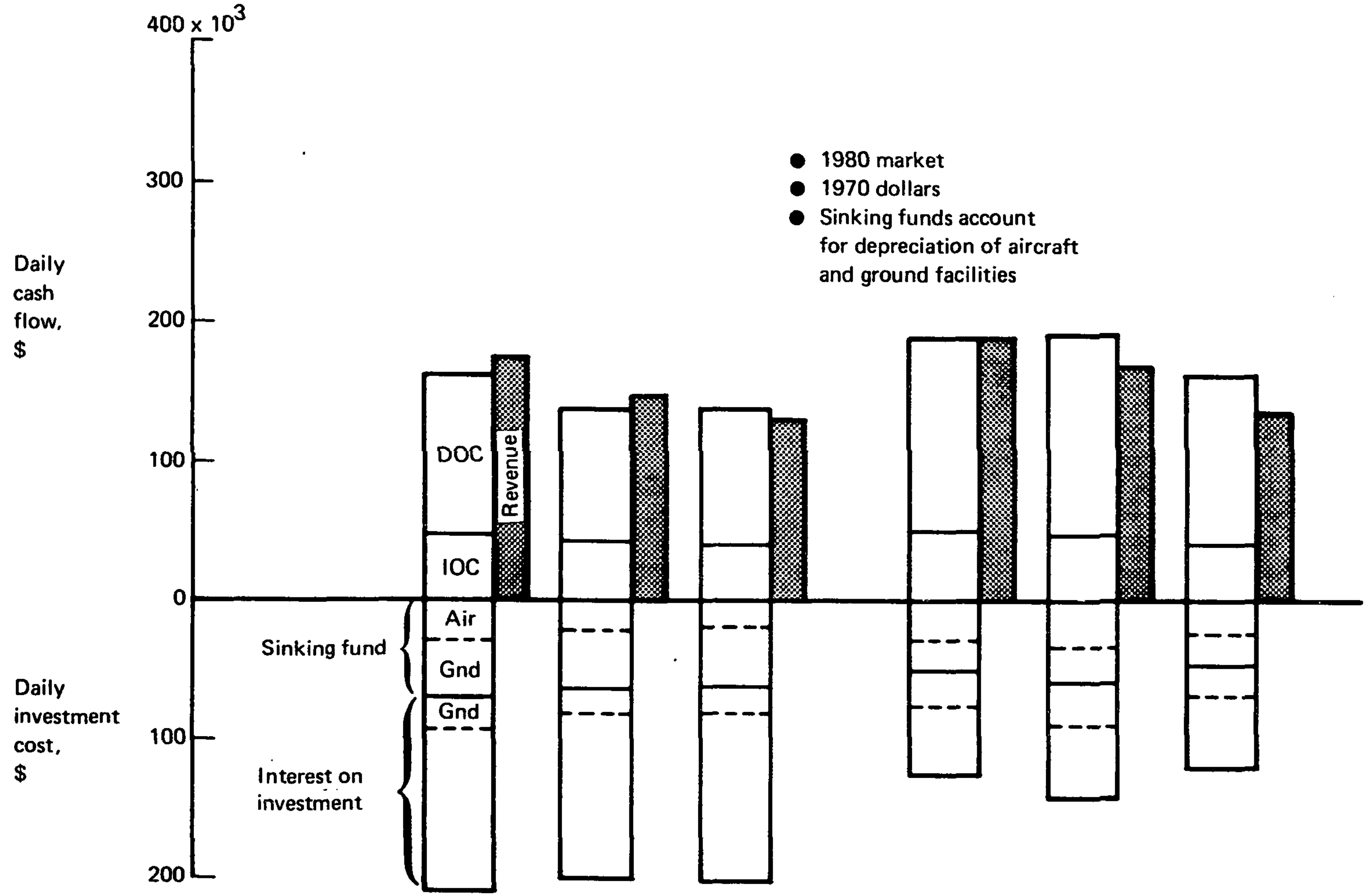
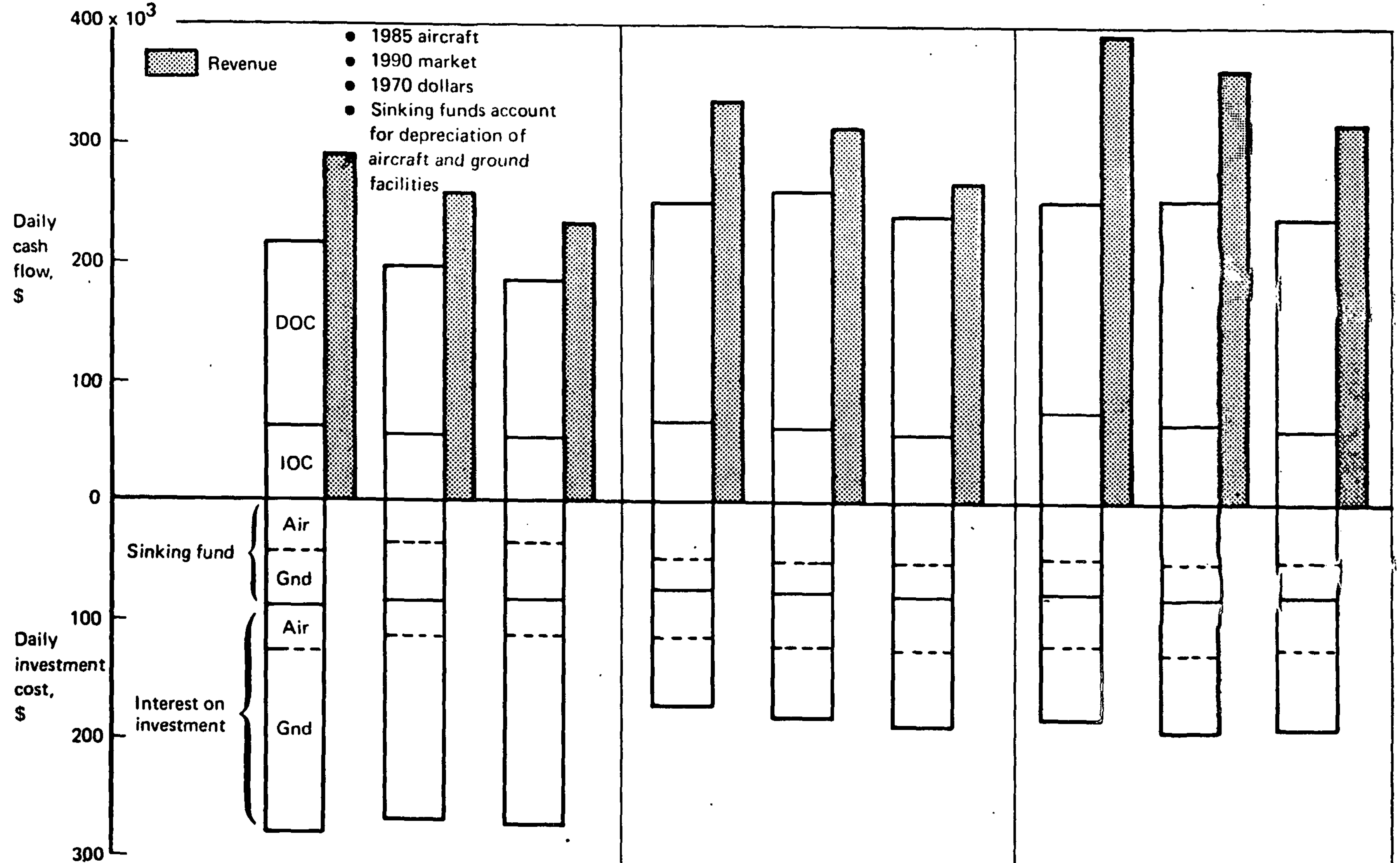


FIGURE 11-45.—EFFECT OF BARTD COMPETITION



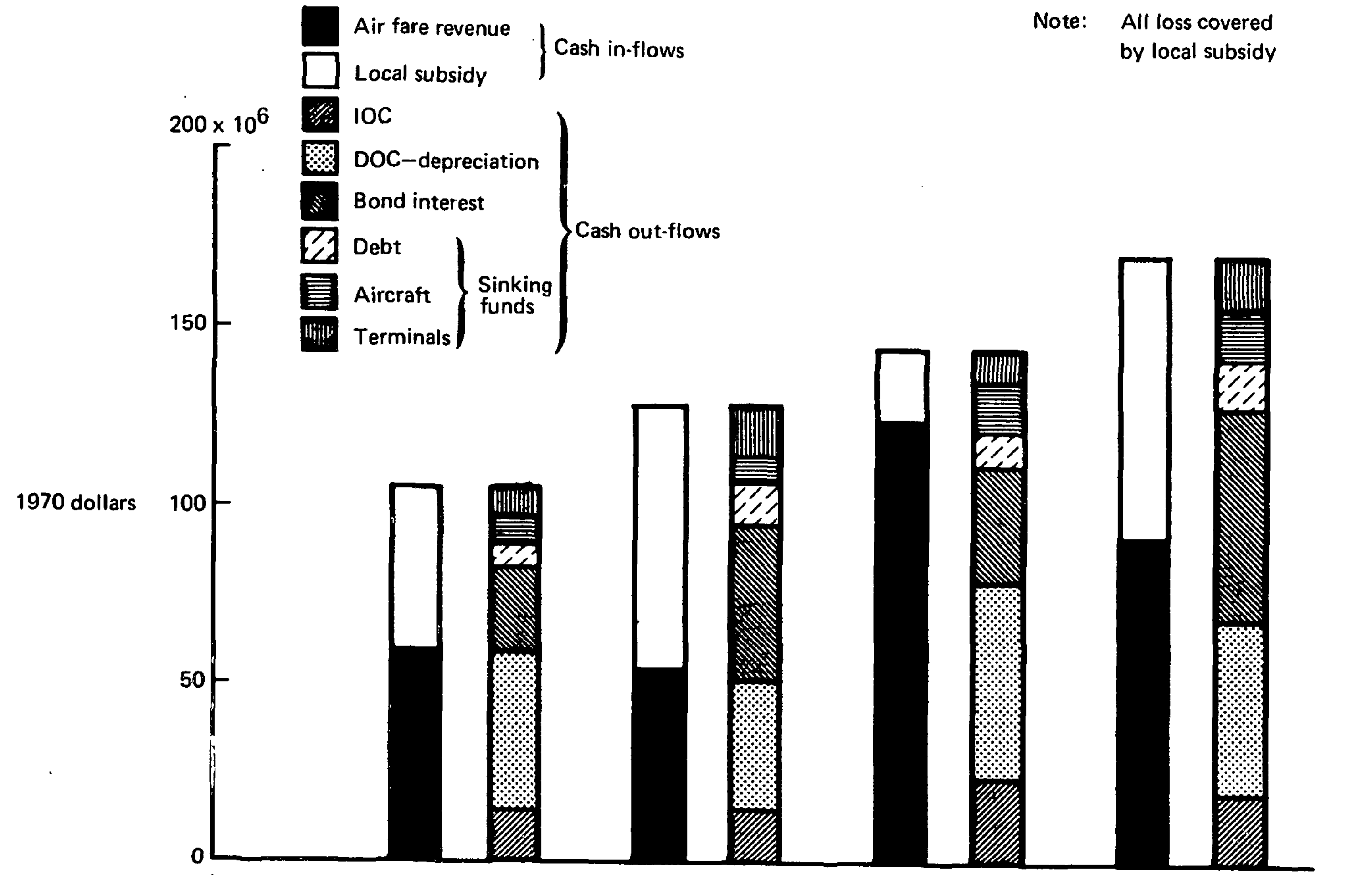
Vehicle	Augmentor wing STOL			Helicopter		
Passengers	49	95	153	50	98	150
Net loss per day	$194 000	$190 000	$208 000	$128 000	$163 000	$147 000
Loss per passenger	$4.05	$4.70	$5.80	$2.42	$3.55	$3.85

FIGURE 11-46.—CONCEPT ECONOMIC COMPARISON—1975 AIRCRAFT



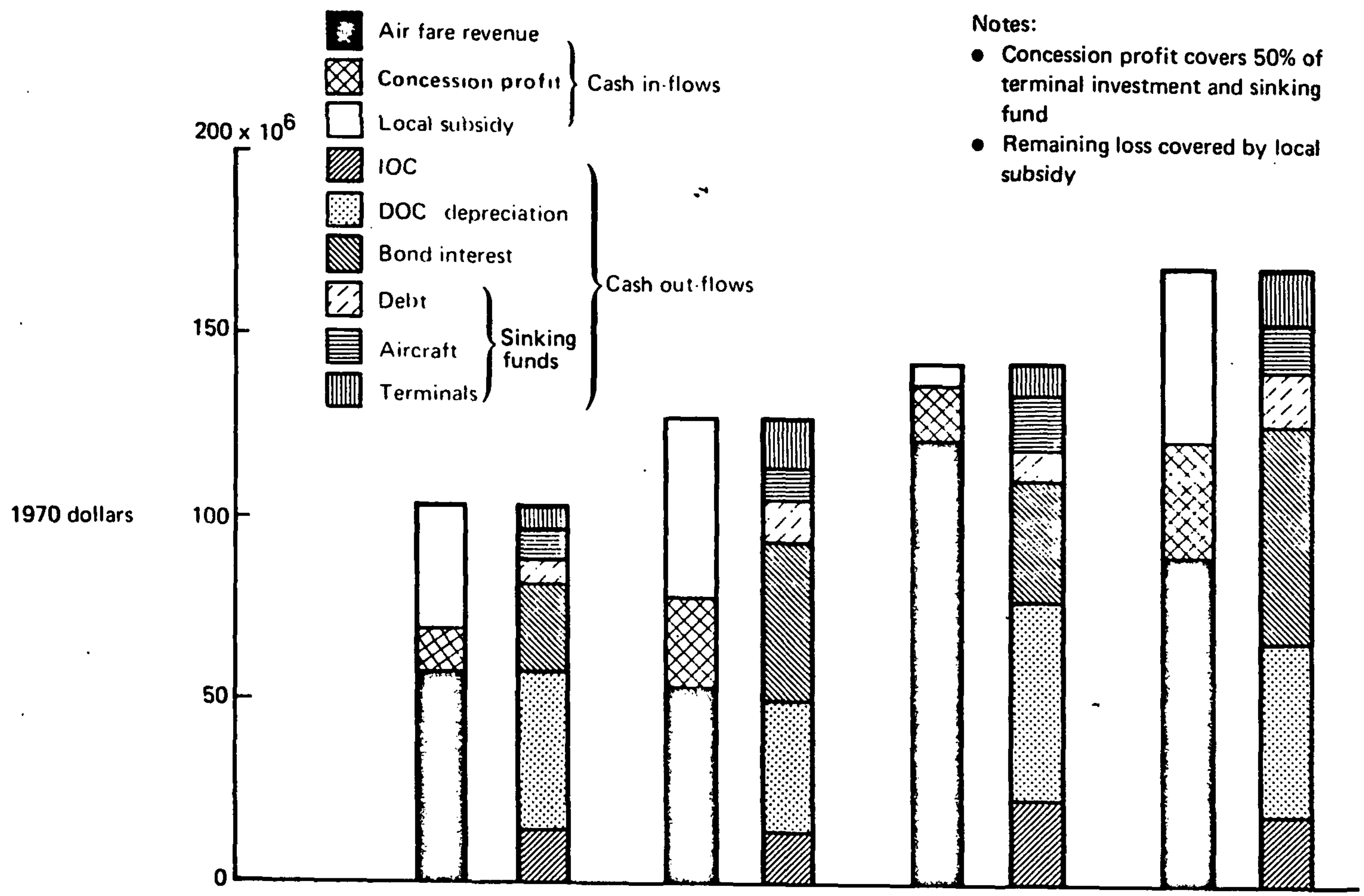
Vehicle	Augmentor wing STOL			Helicopter			Tilt-rotor VTOL		
Passengers	49	95	153	50	98	150	50	100	150
Loss per passenger	$2.65	$3.00	$3.35	$1.05	$1.35	$1.95	$0.40	$0.80	$1.25

FIGURE 11-47.—CONCEPT ECONOMIC COMPARISON—1985 AIRCRAFT



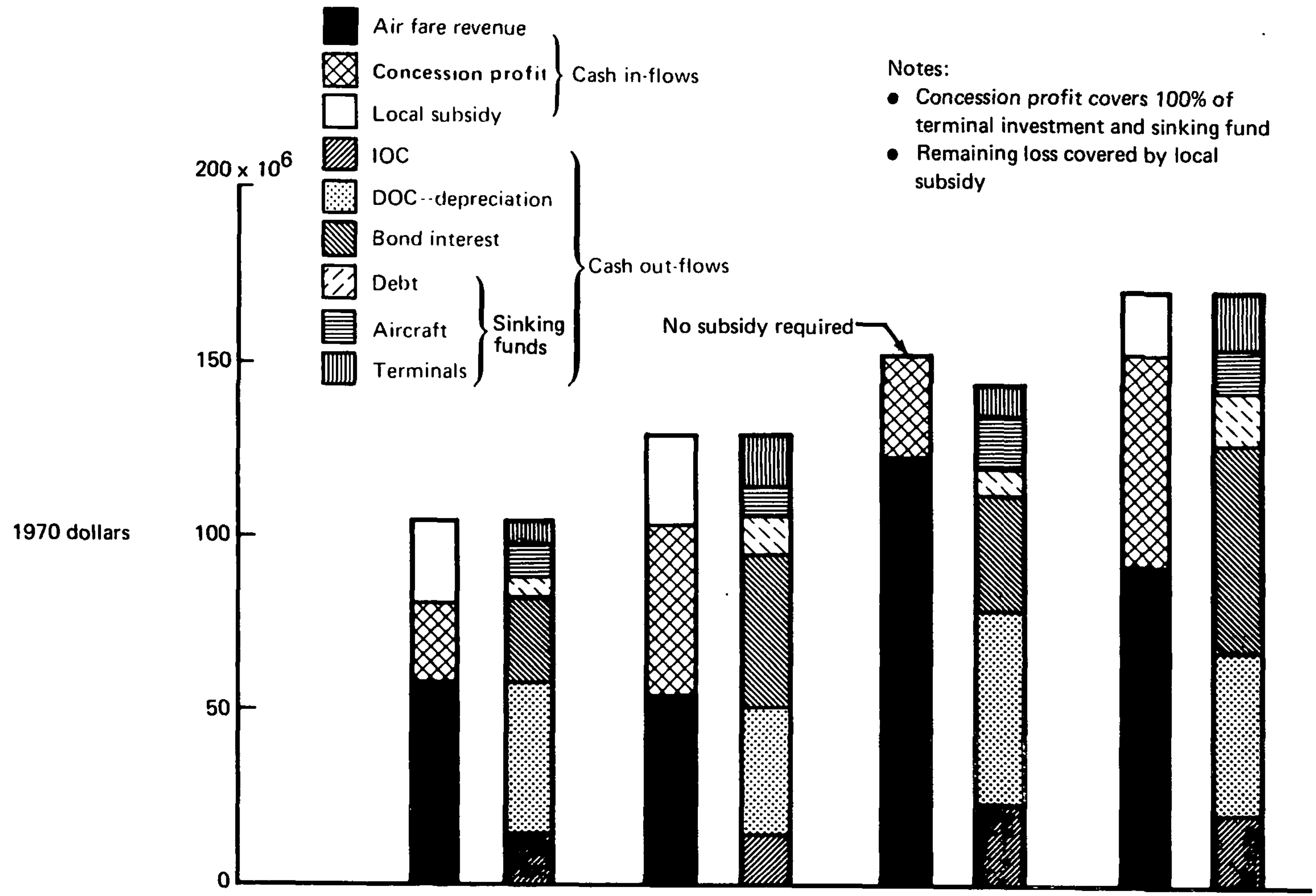
Vehicle	Helicopter	Augmentor wing STOL	Tilt-rotor VTOL	Augmentor wing STOL
Passengers	50	49	50	49
Technology	1975		1985	
Market	1980		1990	

FIGURE 11-48.—ANNUAL CASH FLOW A



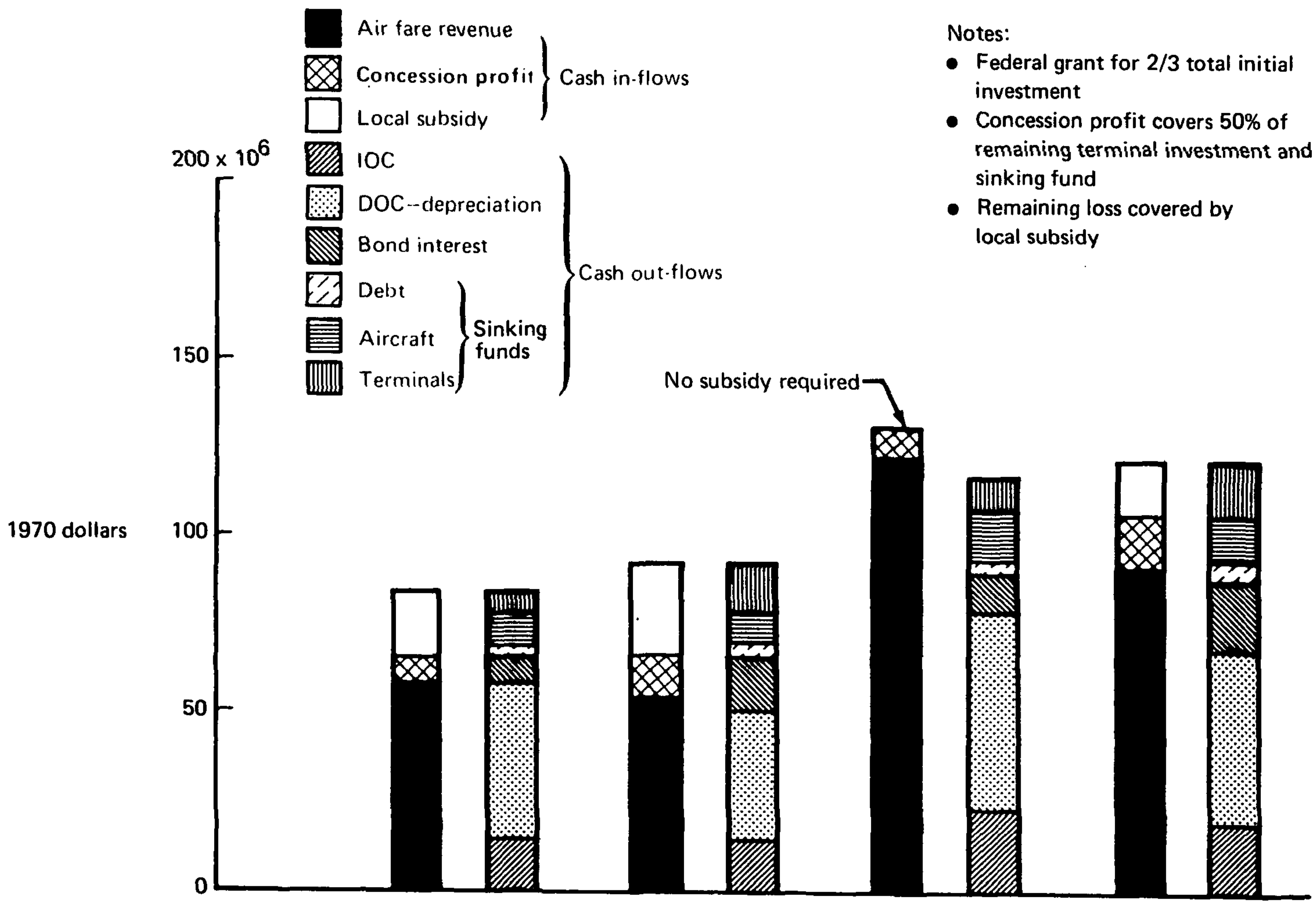
Vehicle	Helicopter	Augmentor wing STOL	Tilt-rotor VTOL	Augmentor wing STOL
Passengers	50	49	50	49
Technology	1975		1985	
Market	1980		1990	

FIGURE 11-49.—ANNUAL CASH FLOW B



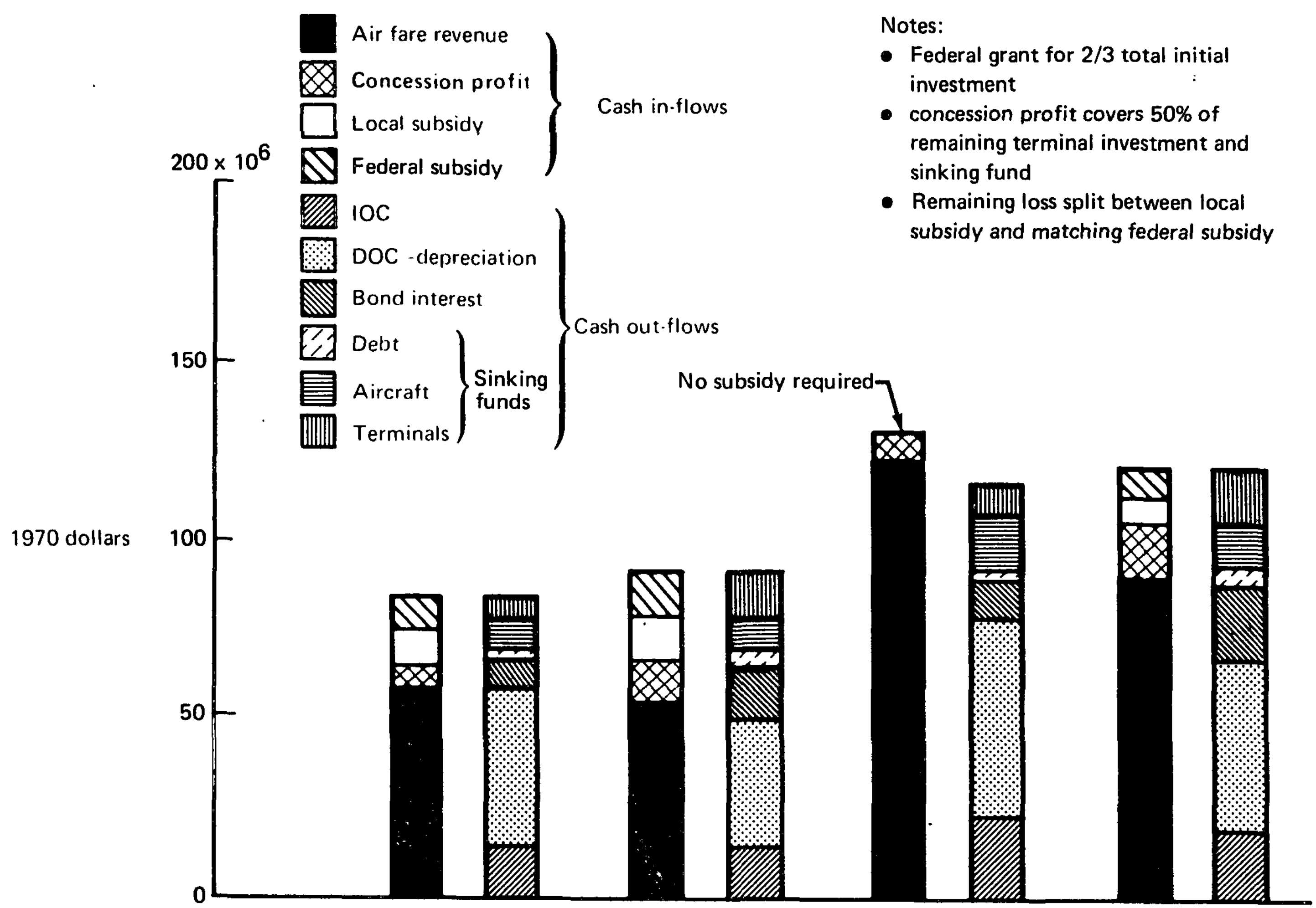
Vehicle	Helicopter	Augmentor wing STOL	Tilt-rotor VTOL	Augmentor wing STOL
Passengers	50	49	50	49
Technology	1975		1985	
Market	1980		1990	

FIGURE 11-50.—ANNUAL CASH FLOW C



Vehicle	Helicopter	Augmentor wing STOL	Tilt-rotor VTOL	Augmentor wing STOL
Passengers	50	49	50	49
Technology	1975		1985	
Market	1980		1990	

FIGURE 11-51.—ANNUAL CASH FLOW D



Vehicle	Helicopter	Augmentor wing STOL	Tilt-rotor VTOL	Augmentor wing STOL
Passengers	50	49	50	49
Technology	1975		1985	
Market	1980		1990	

FIGURE 11-52.—ANNUAL CASH FLOW E

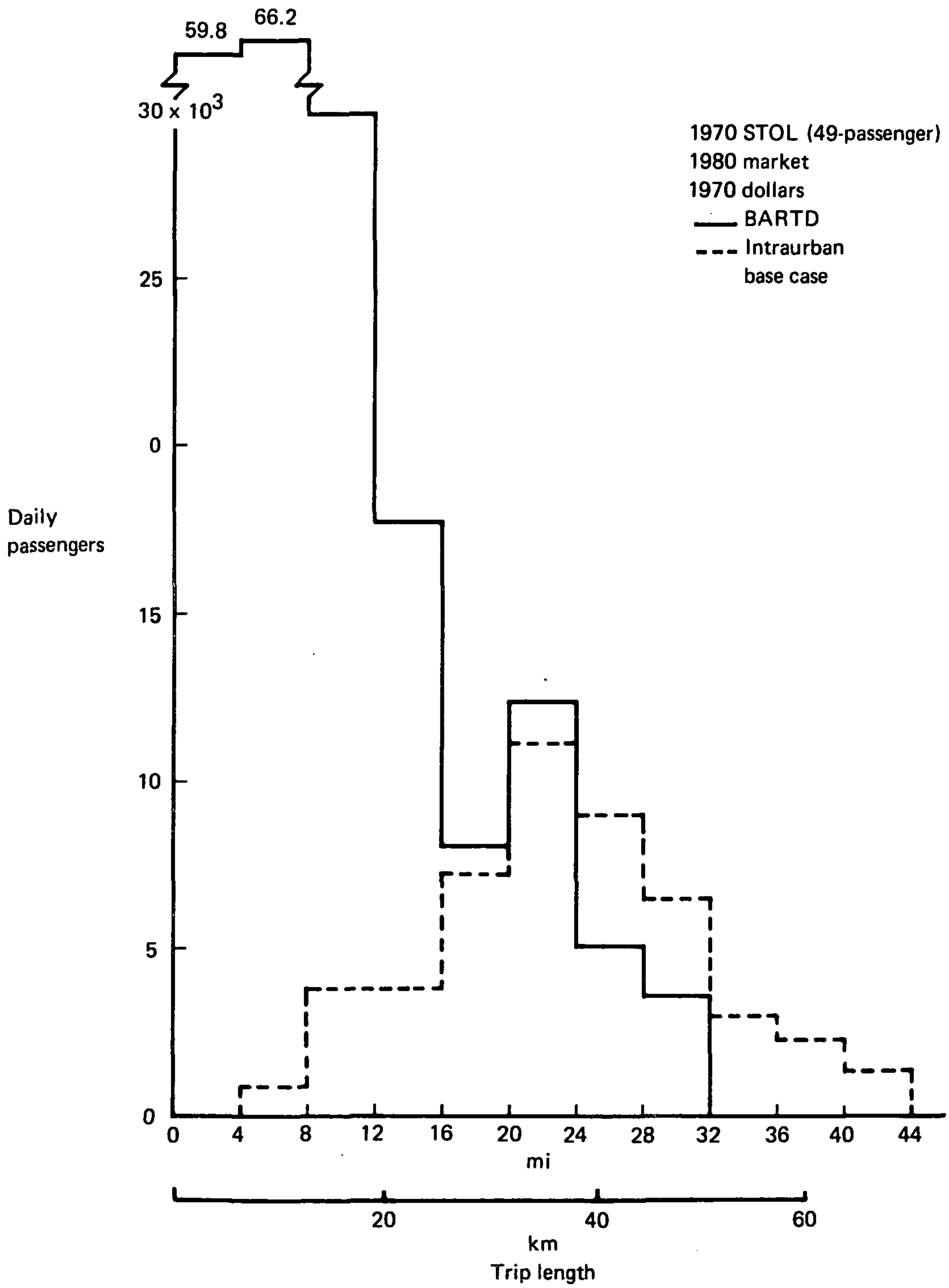


FIGURE 11-53.–DAILY PASSENGERS CARRIED–1980

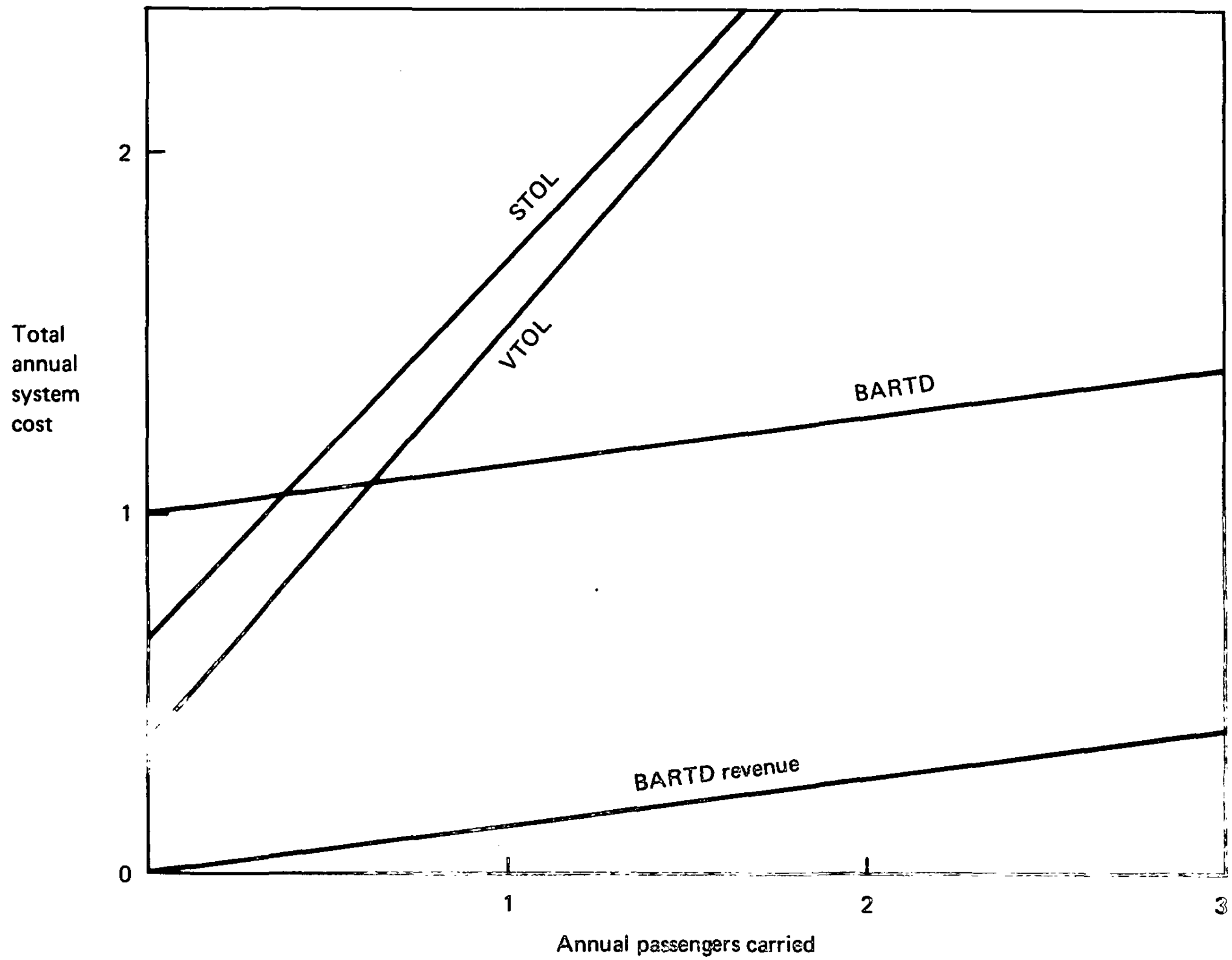


FIGURE 11-54.—EFFECT OF PASSENGER VOLUME ON ANNUAL COST—AIR VS GROUND SYSTEM

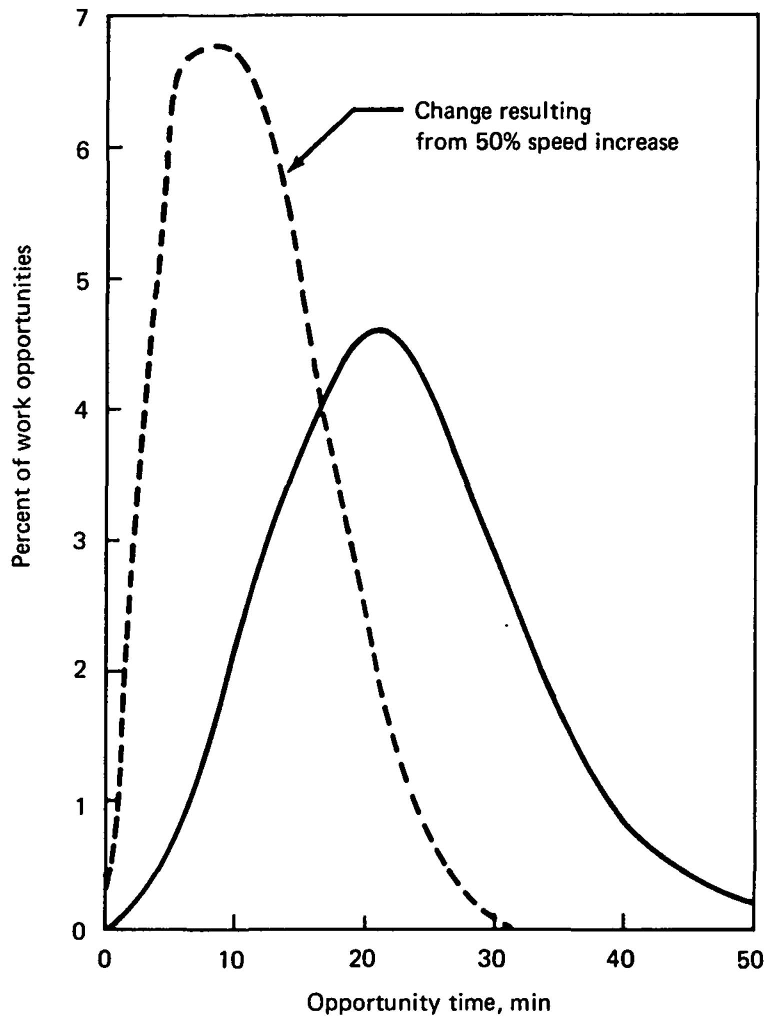


FIGURE 11-55.—CHANGE OF WORK OPPORTUNITY WITH 50% SPEED INCREASE

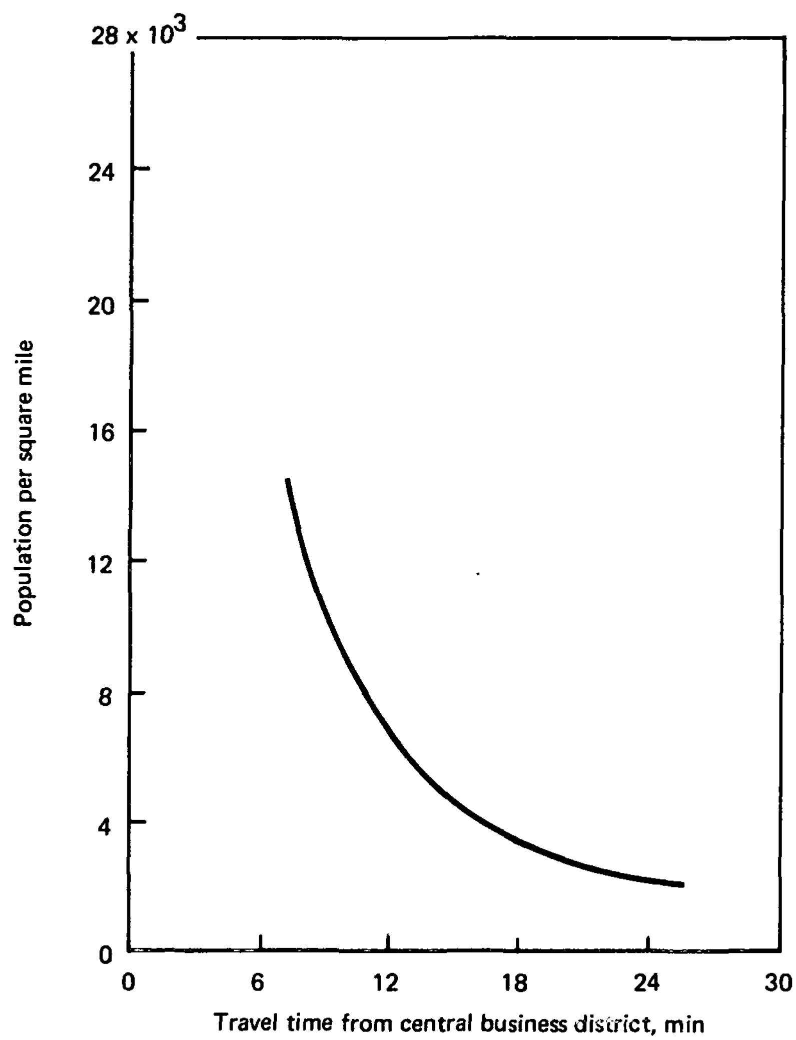


FIGURE 11-56.—CHARACTERISTIC TRAVEL TIME FROM CENTRAL BUSINESS DISTRICT

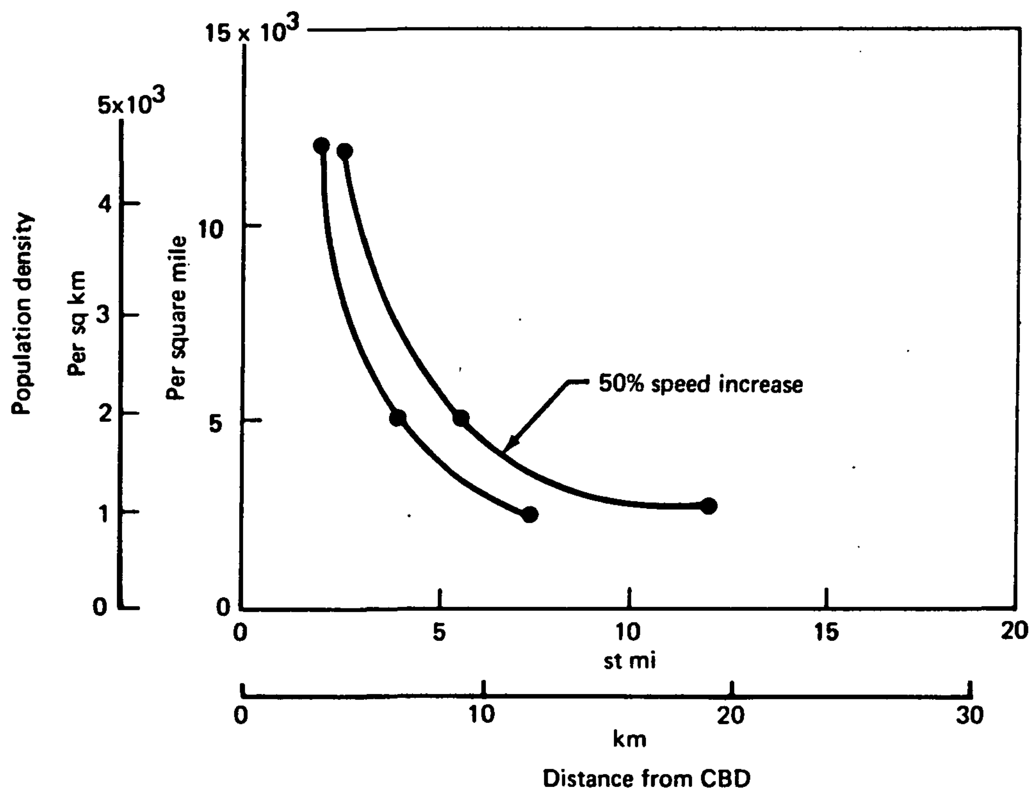


FIGURE 11-57.—EFFECT OF SPEED INCREASE ON METROPOLITAN POPULATION DENSITY

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